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COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

FIFTEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1941).

NOTE.—*A very considerable part of the Council's activities is now devoted to the solution of problems arising out of the war and to assistance and advice to various Government Departments and other institutions and organizations which are concerned with the war effort. This applies particularly to the Council's National Standards Laboratory, the Aeronautical Research Laboratory and the Forest Products Laboratory, and to the Division of Industrial Chemistry. The expenditure on this class of work forms a substantial part of the total expenditure of the Council, but as no specific information which might be of value to the enemy can be disclosed, reference to these activities is either confined to brief generalized statements or is omitted entirely.*

I. INTRODUCTORY AND GENERAL.

1. *General.*—The Council for Scientific and Industrial Research was established in 1926 by the re-organization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920–39, and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries; the training of research workers; the making of grants in aid of pure research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; and the establishment of a bureau of information relating to scientific and technical matters.

2. *The War and the Council's Activities.*—With the outbreak of the war, the Council immediately adopted the policy of re-orientating as much as possible of its work into directions of value to the national war effort. As the war progresses, local production of necessary materials becomes more and more diverse and new emergencies bring new demands in their train. The number of opportunities for diversion of activities is thus an ever-increasing one until to-day a large percentage of the Council's work is in connexion with problems arising out of the war. As stated in the note prefacing this Report, information which might be of value to the enemy cannot be publicly disclosed. Accordingly in the Report that follows it will be found that whereas much of the work of the older "primary industry" Divisions is discussed in some detail, the activities of the newer "secondary industry" Divisions and Sections, if reported at all, is discussed in only general terms.

In common with other organizations, a percentage of the Council's staff has enlisted for one or other of the fighting services. Other officers have been seconded to the Munitions Department and other war-time Departments for the period of the war. The Chief of the Division of Forest Products and a senior officer of the Division of Industrial Chemistry, for instance, are assisting the Department of Munitions in the control of timber and industrial chemicals respectively; the Council's Assistant Secretary (Finance and Supplies) is now acting as Assistant Secretary (Administrative) of the same Department. Other Council officers have gone to other war Departments where their training and experience are valuable. Those who are left are endeavouring to keep the former investigations going, particularly those of a long-dated nature on which time and money have already been spent. Here and there, however, it has proved necessary to cease work on projects until happier times arrive.

3. *Finance.*—The total expenditure of the Council during the financial year 1940–41 was £363,827 of which £70,996 was contributed from sources other than the Commonwealth Treasury. In addition, £8,000 was contributed by the Government of New South Wales for stone facing at the National Standards Laboratory, Sydney. The Council is particularly gratified with the way in which the various contributing bodies continue to support it. Among the many contributions received, reference may be made to those of the Commonwealth Bank, the Australian Wool Board, the Australian Cattle Research Association, the George Aitken Pastoral Research Trust, the Dried Fruit Control Board, and the New South Wales Water Conservation and Irrigation Commission.

II. PLANT INVESTIGATIONS.

1. *General.*—When the previous Report was issued a survey was being made of the pastures of Queensland to determine how best to maintain and improve their carrying capacity. It was found that the most serious deficiency, particularly in the dry winter period, was that of

protein, and no known method is available to make good that deficiency. At the urgent desire of graziers, a research programme directed to the search for and exploitation of both crop and pasture legumes was drawn up. The University of Queensland made available a site for the necessary laboratories at St. Lucia, and negotiations are still in progress for the erection and staffing of the building.

Two conferences of the various Council's and State officers concerned with tobacco problems were held during the year, one in July, 1940, at Sydney, and the other at Canberra in June, 1941. At the former, representatives of manufacturers and the members of the Federal Tobacco Advisory Committee were present and it was agreed that manufacturers would purchase during the 1941 season double the quantity of leaf of the same quality grown in southern areas as was available the previous season. At the 1941 Conference, consideration was given to the position of tobacco-growing in the war effort, to the development of distinct types of leaf, and to balanced production, and recommendations were made to the Australian Agricultural Council.

Experimental plots of opium poppy, digitalis, hyoscyamus, and other drug plants were grown at several selected places, and many collections of material from indigenous plants were made to ascertain alternative sources of certain drugs. A survey is in progress in coastal Queensland areas for this latter purpose.

The Division is continuing its investigations into native or naturalized plants as alternative sources of fibre, particularly as a substitute for jute. The investigations aimed at ascertaining the differences between the fibre from various *Linum* (flax) strains of good type are being continued.

Because most of the countries from which vegetable and farm crop seeds were imported are not now able to supply them, a shortage of some, if not most, of these seeds is inevitable. A survey is in progress to ascertain the position with respect to domestic supplies and methods of maintaining them.

During the year, the Division entered upon its occupancy of the new experiment station area at Dickson, Australian Capital Territory. Also, in Tasmania, work was transferred from the Hobart Laboratory, lent to the Council for the past seven years by the University of Tasmania, to one erected at Huonville in the fruit-growing area. The officer working here will also help the Division of Food Preservation in its fruit juice programme.

2. *Pasture Investigations.*—(i) *General.*—This very important group of investigations includes, in addition to those coming under agrostology, part of the plant introduction and genetics programmes and a study of two pasture plant diseases.

(ii) *Agrostology.*—(*a*) *In Western Australia.*—The value of selected pasture species and mixtures is being studied at eleven centres, mainly in the 17 inches to 25 inches rainfall belt. The results of the past two years' work indicate that *Phalaris tuberosa*, *Ehrharta calycina*, and Wimmera rye-grass are the best of the grasses, and early subterranean clover is the only pasture legume that makes satisfactory growth. Blue lupins have a special value as pure stands on sandy soils. Cape weed (*Cryptostemma calendulacea*) is a serious competitor of sown pastures and methods of reducing its incidence are being studied. The work on variation in *Ehrharta calycina* and in lupins has been continued. Three distinct lines of *E. calycina* are being developed, but a virus disease in the lupins has seriously interfered with the work on these species. The value of blue lupin and of subterranean clover in increasing the soil nitrogen on light, sandy soils is being tested, both by direct measurement of the soil nitrogen and indirectly by recording the yield of Wimmera rye-grass grown in association with these legumes. Blue lupins have responded well to top-dressing with superphosphate, and some response to copper sulphate has been recorded on some of the unproductive sandy soils. Pasture mixtures tried on these soils failed to establish in 1940, but this was partly due to the dry season.

(*b*) *At Canberra, Australian Capital Territory.*—The objects of the work here are (1) to improve native *Danthonia* pastures, (2) to determine the most suitable pasture species and mixtures, (3) to determine the best method of managing sown pasture mixtures. Mid-season subterranean clover can be rapidly incorporated into the natural pastures by surface seeding, sufficient surface cultivation being given lightly to cover the seed, and the pasture top-dressed with from 1 to 2 cwt. per acre of superphosphate.

Present results of the species and mixture trials indicate that *Phalaris tuberosa*, *Trifolium subterraneum*, and *Medicago sativa* are the only species of definite value. Of the remaining 50 grass and 21 clover and legume species tested, the only plants which may prove of some value as secondary species are *Dactylis glomerata*; *Bromus* spp. including *B. unioloides*; *Festuca Mairei*; and Wimmera rye-grass.

The comparison of continuous grazing with monthly and two-monthly rotational grazing of a sown pasture has been in progress twelve months. The pasture is being successfully stocked

at the rate of three sheep per acre, and the larger rotations appear to give some advantage, particularly to the lucerne in the mixture, but it is too early to draw definite conclusions, especially in view of the very dry season experienced in 1940.

(*c*) *At Gilruth Plains, Queensland.*—The study of the Mitchell grass pasture is the main work in progress ; this includes the effect of different rates and times of stocking with sheep on an area of 600 acres of Mitchell grass plain ; the response of the pasture to the excellent summer rains following the three years culminating in the drought of 1939–40 ; the factors affecting the production of hay in Mitchell grass country ; and a test of possible methods of re-establishing Mitchell grass by sowing seed on areas from which the grass has disappeared.

The grazing trial was commenced in February, 1941, with three rates of stocking, viz., a sheep to $2\frac{1}{2}$, 5, and $7\frac{1}{2}$ acres per annum, these rates being imposed continuously, during the summer only and during the winter only. Yield and composition of the pasture as well as the live-weight and wool production of the sheep are being recorded. The experiment is of a long dated character and will continue for at lease five and probably ten years.

The response of the Mitchell grass country to the heavy rains early in 1941 was excellent. Nine and a half inches fell during late December and January, February was dry, but nearly 5 inches fell in March. By this time a yield of 17 cwt. per acre was recorded, but 75 per cent. of the yield was from the annual grasses, mainly Flinders grass and button grass, 10 per cent. was from miscellaneous herbages, and 8 per cent. only came from the Mitchell grasses, the rest being the dry sticks and rubbish remaining from previous growth. The low proportion of Mitchell grasses was due to the low plant numbers and the low vigour of the plants, a result of the preceding three dry years and the drought of 1939–40. However, a good stand of Mitchell grass seedlings has become established on the experimental area ; the seedlings that germinated with the early rains were greatly strengthened by the March rains, and 10 per cent. of them flowered and set seed. Average summer rains next season should enable these plants to become well established, and the stand of Mitchell grass can then be expected to recover fully.

(*d*) *At Griffith, New South Wales.*—Summer and winter growing pasture mixtures have been sown at the Irrigation Research Station, Griffith, New South Wales. The effect of varying the quantity and the time of applying the irrigation water on the yield of the winter growing pasture mixtures is being recorded. Special attention is being given to the relative yield per unit of water used, and the yields from full irrigation of summer pastures and from autumn and spring irrigation of winter pastures are being compared.

(iii) *Plant Introduction.*—(*a*) *At Canberra, Australian Capital Territory.*—During the year, 116 new species and strains of grasses and legumes were grown for the first time in observation rows at Black Mountain, and 350 rows of the more promising pasture introductions were planted on the Experiment Station at Dickson for seed production and further testing. An experiment at Duntroon, in which sixteen of the most promising introduced grasses were tested under plot conditions in various combinations with and without subterranean clover, was completed early in the year. Outstanding features of this experiment, in which *Phalaris*, *Danthonia*, and rye-grass were used as controls, included the high yielding ability of certain introduced strains of *Bromus*, *Festuca*, and *Dactylis*, and the capacity of *Festuca Mairei* and *Bromus inermis* to grow well in association with subterranean clover. Further sward trials are in progress with other introduced grasses and with lucerne varieties.

(*b*) *At Lawes, Queensland.*—Abnormal weather conditions interfered with the work at Lawes, but good progress was made, particularly with tests of some of the introduction selected as promising during previous years. Of these, the grasses *Paspalum scrobiculatum*, *Urochloa pullulans*, *Panicum maximum*, and *Dichanthium nodosum*, and the annual legume *Phaseolus lathyroides* are outstanding. The latter has been found to persist well when grazed in mixtures with grasses, and preliminary tests indicate that it has made good growth at various places in southern Queensland. Observations have indicated that some of these introductions may give their best yields under a system of inter-row cultivation rather than in swards, and an experiment is in progress to test the possibilities of this form of management.

Of the new introductions tested, several species of *Paspalum*, *Panicum*, *Urochloa*, and *Pennisetum* have shown promise, and will be further tried during the coming year.

(*c*) *At "Fitzroyvale", Central Queensland.*—Particular attention has continued to be given to *Stylosanthes guyannensis*, in view of its outstanding promise as a pasture legume for tropical Queensland. Experiments are in progress involving a study of its climatic and edaphic limitations, suitable methods for harvesting the seed and establishing pastures, fertilizer requirements, and the nutritive value of the hay. Other legumes that have shown promise for forage include a variety of pigeon pea from British Guiana, late-maturing soy beans from Java, and species of *Arachis*, *Lespedeza*, *Desmodium*, and *Glycine*.

A number of the more promising introduced grasses have been tested in grazed swards, alone and in mixture with *Stylosanthes*. The highest yields were given by *Bothriochloa glabra*, molasses grass, and the " Kenya No. 1 " strain of Rhodes grass, but, since the more vigorous grasses tend to crowd out the legume, a more balanced pasture may be obtained with other species, such as strains of Guinea grass. Of the more recently introduced grasses, strains of Guinea grass, molasses grass, elephant grass, and *Andropogon gayanus* appear promising.

(*d*) *Co-operative Tests in New South Wales.*—A number of introduced grasses are under test in co-operation with officers of the New South Wales Department of Agriculture. *Agropyron cristatum* (C.P.I. 6607) and *Bromus inermis* (C.P.I. 1967) are showing promise at Glen Innes and Guyra, and a French strain of cocksfoot (C.P.I. 2145) has also done well at Glen Innes, and is particularly promising in the Bathurst district. Seed supplies of these grasses are being built up for distribution to farmers.

(iv) *Pasture Plant Breeding.*—(*a*) *At Canberra.*—The very dry season experienced in 1940 permitted the making of valuable observations on the comparative behaviour of all the strains of the species being investigated. The remarkable range of variation, shown for the first time, in much of the material allowed selections to be made with some degree of confidence, and resulted in the more precise classification of the large number of samples under trial. The investigations concerning *Trifolium subterraneum* were adversely affected by the season, and usually watering had to be done to get seed from the apparently more valuable progenies. The late maturing F5 and F6 hybrid lines performed very well under the dry conditions, but there was no evidence to show that the early maturing material was superior to commercial varieties. Much variation was noted among the 70 samples of *T. glomeratum*, but in general it performed well; selections were made for further testing. The other annual species of *Trifolium* were not impressive under the conditions of the test.

The comprehensive collection of annual species of *Medicago* was added to, and the general performance of the progenies as single plants and in replicated sown swards was observed so that selections could be made for increase and breeding. Further studies were made on the flowering and fruiting characteristics of the better known species, and desirable intra-specific crosses made. Inter-specific hybridization between apparently closely allied species was attempted on a reasonably large scale, but with little success. Certain medic progenies appeared to be most promising; the critical testing of these lines in their appropriate areas seems to be well justified.

Further work was done on the three strains of *Dactylis glomerata* selected as the most hardy of all available samples. The first improved progenies are being increased and tested under sward conditions at various rates of seeding. Further improvement by re-selection is being attempted. Strains of *Danthonia* species did very well in the adverse season. Two hundred and forty single plant selections have been made and these progenies are being tested as swards and single plants. They will all be increased to provide material for possible extensive testing. The selected smut-resistant strains of *Bromus catharticus* and allied species have been further tested under grazed sward conditions and seed increased.

(*b*) *At Lawes, Queensland.*—Work on lucerne, other species of *Medicago*, and on Rhodes grass was carried on during the year. Observations were made on some medics, on *Phalaris*, and on native legumes and grasses. Variations within the strains of lucerne, especially with a view to their use in developing better (1) hay, and (2) pasture types, were observed and selections made. Experiments were made to determine percentage survival; the best surviving strains found were four Australian and one from the Argentine. Selections were also made on high yielding strains; these indicated that Australian and Argentine materials were superior to others. In selecting for high yielding types, several desirable characters were also looked for: these included two types of growth, upright or prostrate, early maturing types, those with a long-growing season and desirable crowns, seed production, disease resistance, and ability to compete in pastures. Several crosses have been made in order to obtain progeny combining these characters. The programme for the improvement of *Phalaris* was continued, attention being given to survival of desirable plants from which selection for seed production will be made later on. Some of the problems being dealt with in the work on Rhodes grass include trials of selected clonal progenies as well as trials of new introductions and new collections from outstanding local material. One strain has consistently shown great promise at Lawes, Kingaroy, Biloela, and on the Atherton tableland.

(*c*) *At Moss Vale, New South Wales.*—The continued rainfall deficits at Moss Vale have adversely affected the progress of the work there. For example, the past season was too severe on subterranean clover to enable a proper judgment to be made of its value in the district. Investigations into dormant and hard seeds were continued. With red clover (*T. pratense*) an experiment designed to determine whether seed was produced under the environmental conditions obtaining at the field station gave positive results; in other words, red clover

seed was produced without the use of the bumble bee. Strain trials are being continued using Montgomery Late, Broad Red, Danish Tystofte, and a mixture of two German regional strains. The breeding of special strains of white clover (*T. repens*), such as of Ladino or Wild White, has been continued. Strain trials included a group sown in 1940, of which T.R.—30 was the best during a year's observations, a group of seven strains from the United States of America, Germany, Roumania, New Zealand, and Victoria, and a group of 22 strains recently collected by the Plant Introduction Section.

Strain trials of perennial rye-grass begun in 1939 were continued, and in addition Clunes, Colac, New Zealand Mother, New Zealand Bred, Moss Vale Regional, and Tasmanian Regional strains were sown at the field station and also in Victoria and Tasmania. Cocksfoot (*Dactylis glomerata*) suffered from drought conditions, but the Welsh strains appeared to be hardy and are still showing well in the swards. A seed production trial was commenced to obtain as much information as possible which may be of immediate use by seed growers.

(*v*) *Diseases of Legumes.*—Work was begun on several viruses affecting legumes. Preliminary trials were made with jassids to determine whether or not they are vectors of witches' broom of lucerne, a disease that is of some importance in limited areas in New South Wales and Queensland. A disease of lupins in Western Australia is also being studied.

3. *Weeds Investigations.*—(i) *In New South Wales.*—(*a*) *Skeleton Weed* (*Chondrilla juncea*).—This weed cannot be controlled by any tried chemical, and the trials have been concluded. The best method of reducing the effects of skeleton weed in wheat areas is by sowing lucerne and by modifying the wheat-fallow rotation to increase the proportion of grazing in the rotation. The field experiments on these lines are being done by the New South Wales Department of Agriculture at their Wagga Experiment Farm.

(*b*) *St. John's Wort* (*Hypericum perforatum*).—St. John's wort can be virtually eliminated wherever subterranean clover can be grown successfully. In the Mannus Valley near Tumbarumba, a pasture mixture of *Phalaris tuberosa* and subterranean clover sown on fallow and top-dressed annually with superphosphate has been practically weed-free for nearly four seasons. Perennial rye-grass and Wimmera rye-grass in combination with subterranean clover are not quite as effective, and plots sown with white clover as the associate legume have given relatively unsatisfactory results. Subterranean clover alone, sown on land top-dressed with superphosphate, has given satisfactory control even in a dense stand of the wort. The control of St. John's wort is, therefore, largely a matter of applying known principles of pasture improvement, viz., the improvement of soil fertility by introduction of clover, the use of phosphate, and the incorporation of a suitable perennial grass such as *Phalaris tuberosa* in the pasture mixture. In southern New South Wales and north-east Victoria, wherever the land is not too rough and steep, improved pastures should be the means adopted to control the weed. In the Mudgee district these methods of pasture improvement are not practicable, because the dominance of the summer rainfall precludes the use of subterranean clover.

(*c*) *Blackberry* (*Rubus fruticosus*).—Spraying with chemicals has not been successful in controlling an infestation of blackberry in an orchard at Batlow. Chlorates killed the aerial shoots, but regrowth was both rapid and strong, and these regrowths showed, if anything, greater resistance to subsequent sprayings. Where land can be brought under the plough and used for pastures, good results can be achieved by sowing mixtures based on perennial rye-grass and white clover or subterranean clover, provided the pastures are grazed—preferably with sheep—and some attention devoted to dealing with the regrowths to keep them from re-infesting the area.

(ii) *In Queensland.*—The work on both nutgrass (*Cyperus rotundus*) and mintweed (*Salvia reflexa*) has shown that chemical sprays are of no practical value in controlling either plant. Clean cultivation, at fortnightly intervals, of land heavily infested with nutgrass has killed almost all the weed, but the practicability of this method is very doubtful, and until it is known how long the effect will last, and what advantages are derived by the crops, no decision on this point can be made.

At Pittsworth, Queensland, on land heavily infested with mintweed, wheat was grown on two-year, one-year fallow, and no fallow. One-year fallow gave satisfactory wheat yields, but no further advantage was gained from two-year fallow. No fallow gave very poor yields because of mint-weed competition. Contrary to expectations, complete exclusion of stock from land carrying mintweed has not resulted in any material increase in the number of desirable plants nor has there been any diminution of mintweed.

The effect of controlled stocking on an area of land carrying galvanized burr at Warrie Station near St. George, Queensland, has been recorded for over four years. A dense stand of native grasses has become established on the area, but so far the density of the burr has not lessened. Excellent summer rains in 1941 may, however, cause the balance to be changed.

(iii) *In Victoria.*—(*a*) *Hoary Cress* (*Lepidium draba*).—Hoary cress is regarded as the worst weed in Victoria, 94,000 acres being infested. It is of greatest concern on the wheat lands of the central Wimmera, but it has been reported from practically every district of Victoria. Small local infestations occur in South Australia, New South Wales, and on the Darling Downs in Queensland. A detailed study of the effect of chemical poisons applied both as sprays and directly to the soil is in progress, in part near Murtoa and in part near Werribee. Trials of the value of pastures for control of the weed in the Wimmera have had to be re-sown in 1941 because of the extremely dry season of 1940.

(*b*) *Water Reed* (*Phragmites communis*).—Sodium chlorate solutions from 2½ to 15 per cent. are almost equally effective in killing the aerial part of the plants, and regrowth following the spraying is slow. It is expected that this method of dealing with the pest in irrigation channels and ditches will be economic, and large scale tests are being conducted near Leeton in collaboration with the New South Wales Water Conservation and Irrigation Commission.

(iv) *In Western Australia.*—Chemical poison sprays are being tested for killing Berkheya thistle. This work is being dome in collaboration with the Department of Agriculture.

4. *Wheat Investigations.*—(i) *Take-all and Root Rot.*—Field experiments on this group of diseases were continued during the year at three sub-stations. Detailed studies were possible on the 9-acre plot near Duntroon, where take-all again appeared in severe form, though not in the same patches as in the previous year. Seedling blight was common ; it occurred in patches, and there was a correlation between the positions of such seedlings and the subsequent development of take-all at heading time. The work is being repeated. Root amputations showed that during the exceptionally dry growing season in 1940 the plants depended mainly on their seminal root systems for moisture throughout the growing period. This helps to explain the unusually severe injury caused by early infection of the sub-crown internode or seminal roots with *Ophiobolus graminis* in the same field.

No differences in physical nor chemical composition have been detected in a yet incomplete series of analyses of soils from patches bearing healthy and others bearing diseased plants. Neither diseased nor healthy plants responded to 2 cwt. per acre of sodium nitrate nor ammonium sulphate applied as two top-dressings in spring. Lack of moisture may have been partially responsible for the ineffectiveness of these treatments. The distribution of diseased plants could not be correlated with differences in the compactness of the soil. Throughout the season the microflora of roots of wheat in the same field was determined, the dominant organism from the seedling stage to early maturity being *O. graminis*. From then on, species of *Fusarium*, *Helminthosporium*, and *Alternaria* were much more evident.

In 1938 at Canberra, large amounts of some calcium, magnesium, potassium, and sodium compounds were added to 5-gallon drums of soil, and crops of wheat were grown in each successive year. The results obtained during this season were essentially the same as those of the previous year, the differential response to the soil treatments being again most striking. Plants in all drums to which lime alone or together with other compounds was added made very much better growth than others without lime. At maturity, detailed examination of the plants was made. The average weight and condition of grain from each head and the condition of the roots were determined and were used as criteria in evaluating the influence of the soil composition on take-all, and the differences were highly significant. In other experiments in which another lot of soil was used, highly significant differences were also obtained between crops in drums that were inoculated in the preceding year with *O. graminis* and others that were not inoculated. The latter were badly affected, the former not at all. The difference between the behaviour of the previously inoculated and the control drums appeared to be associated with the greater loss of soil nutrients to the heavier crop in the uninoculated drums during the preceding year. An experiment is now being made to find out if this is so, and whether the organism also may have contributed by exerting some beneficial influence on the soil.

Genetical studies of the organism were made. Variation in pathogenicity to the wheat plant and culture colour on potato agar are heritable. The growth factors required by the organism on synthetic media are thiamin (Vitamin B_1) and biotin (Vitamin H). Other physiological studies are being continued.

(ii) *Yield.*—Investigations are being continued in order to obtain fundamental information in regard to yielding ability, which should be of value in planning crosses, and in selecting high-yielding plants in breeding programmes, and which should enable higher yielding varieties to be produced. Results of investigations conducted in previous years show that, in general, yield attributes such as number of ears per plant, number of grains per ear, and average grain weight, are independent of each other. Attempts are being made to combine in one variety high values of each of these attributes, and so produce varieties with higher potential yielding ability. An experiment has been conducted to determine the magnitude of the effects of

competition between plants upon characters associated with yield, and it has been demonstrated that results of such competition are sufficiently great to account for the fact that single plant selection, as usually practised, for yielding ability in segregating generations of wheat crosses, has been ineffective. Experiments to investigate the possibilities of various improvements in the technique of selection are in progress.

5. *Vegetable Fibre Investigations.*—(i) *Flax* (*Linum usitatissimum*).—Although it is now established that the Liral, Stormont, and other recently developed strains of *Linum* give appreciably higher yields of fibre than the old Baltic or Riga flax, there are evident differences among the new strains. With a view to determining the differences in yield, quality, size, strength, arrangement, &c., of the fibres, eighteen strains were grown in Canberra. By arrangement with Professor Ashby of the Botany School of the University of Sydney, representative samples of the stems were sent to the Botany School where exhaustive examinations were made to detect such differences. The work is still in progress, but so far it may be said that the Stormont strains tend to be better than the others both in yield and quality.

In addition, two of the improved strains, Liral Crown Norfolk and Liral Egypt, were grown along with a commercial Blue Riga as a check in a fertilizer trial planned to find out the effects on fibre of lime, phosphorus, and potash. Indications are that although phosphorus may increase yield of straw it depresses the quality of the fibre, whereas potash improves fibre quality. These experiments are being repeated because conclusions can be drawn only from the results obtained during several seasons. Trials are in progress in co-operation with the Department of Agriculture of Western Australia testing two Liral and two Stormont strains with Blue Riga as a check.

(ii) *Other Fibres.*—A sufficient quantity of stems of *Urena lobata* to enable a small bulk trial to be made of the fibre was obtained through the South Johnstone Tropical Research Station of the Queensland Department of Agriculture and Stock. This was submitted to a cordage manufacturer of Sydney who reported favorably on the test, and suggested the desirability of a trial cultivation of the plant because of the variability of the wild material. Plans are in hand to grow a plot of *Urena lobata* as a fibre crop.

Small scale trials are in progress with hemp (*Cannabis sativa*), jutes, and Crotalarias.

During the year many samples were received from various sources for the determination, of fibre content and value. These include such as *Sida rhombifolia*, *Triumfetta* sp., *Cryptostegia* sp., *Pepturus* sp., nettle, and yucca.

6. *Tobacco Investigations.*—(i) *General.*—During the year, the work on chemistry of tobacco, at the University of Sydney, was discontinued, as was also the study of disease resistance by the Division's Section of Genetics. These investigations will probably be resumed at a more appropriate time. An entomologist is now actively co-operating in the work on the yellow dwarf disease. Smoking quality and physiological investigations were continued. Co-operative work with the States has been maintained on the same basis as previously, and two conferences of Commonwealth and State tobacco officers were held; the main features of these have already been reported.

(ii) *Yellow Dwarf.*—In general, the programme of experimental and field work was similar to that of the previous year. At Shepparton, most of the plants in the field plot became infected during the latter half of November and the first week of December. This was about one month earlier than in the previous season; nevertheless, data on occurrence of the disease and vector populations for several years indicate that infection occurred within the normal period. Insect transmission of the disease was again obtained with a brown jassid *Thamnotettix argentata* Evans, best results being secured with insects collected during late November. The minimum incubation period of the disease in the plant under both laboratory and field conditions was ten days. Alternate host plants of the vector and the virus are being investigated. At Nathalia, four acres of two varieties of tobacco were planted, using seedlings from seed of yellow dwarf plants and from others apparently resistant to the disease. There was a high percentage of infection in the field and no indication of disease resistance was obtained in either variety.

(iii) *Physiological Studies.*—Because of the importance of a high content of reducing sugars for good quality, a study has been made of the behaviour of the carbohydrate in the leaf during its development on the plant, and during its subsequent curing. Particular attention was paid to what has been termed the "labile reserve" fraction, which represents by far the greatest fraction of carbohydrates in the living leaf. During curing, the labile reserves are largely broken down to reducing sugars; it is, therefore, considered important that tobacco should be grown under conditions conducive to accumulation of this reserve carbohydrate fraction. A comprehensive study has also been made of the effect of drought on the growth of the plant and on the composition of the leaves. Drought was found to lead to delayed and unsatisfactory ripening; it caused a high content of nitrogen in the leaves, and a low content

of labile carbohydrate reserves. These results are regarded as factors conducive to bad quality. The work on water requirements of tobacco is of particular importance in Australia, because irrigation is necessary as a supplement to rainfall in some of the main producing areas.

(iv) *Smoking Quality.*—The results of smoking tests conducted on tobacco leaf samples received from the various State Departments of Agriculture, and representative of the 1935–40 crops, were summarized. They show that the four main producing areas, North Queensland, Queensland-New South Wales border, north-east Victoria, and the south-west of Western Australia, each produce a different type of flue-cured tobacco. About 90 per cent. of our tobacco leaf is grown in these areas. There are at least eleven different types of flue-cured leaf grown in Australia, some in small quantities. Climatological data and the results of chemical analyses, particularly of organic constituents, of leaf from various districts, support the division into types based on smoking quality. Climate and soil determine the type of tobacco produced, while seasonal conditions and cultural practices may modify quality within the type. Smoking tests conducted in co-operation with the States were continued with samples representative of the 1940 crop.

7. *Fruit Investigations.*—(i) *Apples.*—(*a*) *In Tasmania.*—The year has seen considerable changes in the organization of the work. In the first place the laboratory has been transferred from the accommodation provided by the University of Tasmania for the past seven years to Huonville, an important apple-growing centre and within easy reach of important small-fruits areas. A laboratory has been erected on land provided by the Tasmanian Department of Education with a small nursery of half an acre adjoining. All the equipment has been transferred and re-erected, and experiment trees have been successfully transplanted to the nursery.

The war has been responsible for a diversion of effort and a greater emphasis on certain aspects of the work. These involve an extension of the experiments with wax coatings and a re-organization to co-ordinate with the wider attack on this problem organized by the Division of Food Preservation. In connexion with one of the wider aspects of this problem undertaken by the Division of Food Preservation, the internal atmosphere of the fruit, a re-examination and summary of the results of the work carried out in Tasmania on the brown-heart problem over the past five years has been made.

Another feature of the past season has been the extended co-operation with the Tasmanian Department of Agriculture in experiments, particularly in relation to the effects of different stocks and pruning techniques on the keeping quality of apples.

Field Disorders.—The 1939–40 growing season was characterized by low average temperatures and drought conditions. This affected fruit size to such an extent that the actual incidence of many disorders associated with dry conditions was low.

Owing to the general adoption of methods demonstrated in our experiments, internal cork is now uncommon and no indication of the relative incidence in 1940 was obtained. Experiments to determine the duration of the effect of soil dressings have shown that the effect of $\frac{1}{2}$ lb. to 1 lb. of borax per tree has continued for five years at least. Injection experiments to test all likely deficiencies have failed to demonstrate a likely cause or cure of a condition known as "dimple". Preliminary grafting experiments have failed to demonstrate that the disease is caused by a virus, but further grafting experiments are in progress in the nursery now available. Owing to the succession of dry seasons, physiological dieback is becoming increasingly prevalent on the poorer soil types, probably as a result of deterioration of soil structure due to lack of organic matter, but improper pruning methods may also have contributed.

Storage Disorders.—The season 1940 was characterized by a crop of very small fruit, and, as was expected, the incidence of storage disorders was low. These did occur, however, and it was found that the comparative incidence of breakdown, lenticel scald, and light scald was high, of pit moderate, and of Jonathan spot and deep scald low. The mathematical relation of percentage disorder and the chemical and physical properties of the fruit to the average size of the fruit per tree (a measure of the leaf : fruit ratio) has now been established for five successive years. These results now form a basis for recommendations for the most satisfactory average size for several varieties and a background for the necessary thinning and crop control experiments to obtain this.

As there is generally some delay in placing fruit in cool storage, experiments have been in progress for the past six years to determine the effects of delay on the incidence of storage disorders in susceptible varieties. With Cox's Orange Pippin, delay in cool storage has proved to be uneconomic. The advantages of an occasional reduction in the percentage of disorder and the opportunity for culling fruit which become affected during the period of delay, were more than outweighed by the general deterioration in condition and maturity. In some seasons

there has been a definite increase in the amount of disorder. With Jonathan, the incidence of breakdown was greatest with immediate storage, deep scald after a delay of one week, and Jonathan spot after a delay of two or more weeks. On the whole the advantages were with immediate storage. In the case of Cleopatra, there was a significant reduction in the incidence of pit when storage was delayed for two weeks. Provided shrivelling and yellowing are controlled, storage may be delayed with no ill effects and often with advantage.

Fruit Physiology in Relation to Keeping Quality and Seasonal Climate.—Studies of the chemical and physical characteristics of the different tissues within the apple fruit in relation to development, variety, seasonal climate, &c., have been continued, and, on the basis of the experience now available and such tests and climatic data in January and February, forecasts are being made of the keeping capacity and susceptibility to disorders of the fruit in the coming seasons. This is already proving of practical value in the management of cool stores. The relation of seasonal climate to incidence of disorders is now becoming clearer, and relations are being found, some of which confirm theories advanced in the United States of America.

Experiments with Artificial Atmospheres.—Originally designed to find critical data concerning the incidence of brown heart in apple cargoes shipped from Tasmania, these experiments have now served their original purpose. Certain aspects are being continued as part of a larger scheme to investigate the respiratory relations of fruit, and data with respect to seasonal incidence, crop factors, and physiology of ripening were desired. The general results on the brown heart problem are as follows :—

Susceptibility to brown heart varies considerably. Sturmer is very susceptible, French Crab, Scarlet, Cleopatra, Tasman's Pride, Cox, and others are less susceptible, whereas Jonathan, Granny Smith, Democrat, and Crofton are resistant and rarely affected. Susceptibility varies from season to season in the fruit from the same trees, and a difference in susceptibility has been found in Sturmers grown in different soils. Susceptibility is greater in fruit from light crops than in that from heavy crops. Susceptibility increases with the maturity of the fruit at picking time.

With varying susceptibility of fruit it is obvious that the concentration of carbon dioxide required to cause injury varies also. The longer the period the fruit is exposed to any concentration, the lower the latter must be to ensure freedom from brown heart. In 1937, the maximum safe concentration for May-picked Sturmers was about 3 per cent. for a storage period of eight weeks and 10 per cent. for a period of seven days, and these may be regarded as desirable commercial limits for ships. Relatively early in the season low temperatures (32°–34° F.) appear to be more dangerous with a given concentration of carbon dioxide than higher temperatures (38°–40° F.). Later, when the fruit is more suspectible because of delayed picking or delayed cooling, higher temperatures become dangerous, and the highest (50°–60° F.) appear to do the most damage. Concentrations of carbon dioxide insufficient to cause brown heart may quickly stimulate low temperature breakdown in susceptible varieties. The symptoms of brown heart do not develop as soon as the fruit is injured. In short storage periods of two or three weeks brown heart does not become evident in the fruit until it has been exposed to air at ordinary temperatures for about 48 hours.

Pre-storage Treatments.—Work on pre-storage treatments to increase the cool and common storage capacity has now been greatly expanded on account of the war conditions, and the Tasmanian experiments have now been merged into a wider scheme in co-operation with the Division of Food Preservation. Surface coating experiments were designed to discover the most useful and economical type of coating for Tasmanian varieties, the effect of the coatings at cool storage temperatures, and the effect on fruit held in common storage.

These experiments have indicated that the process may have considerable commercial possibilities if over-maturity is avoided. The method is more suitable for uncoloured varieties. In Tasmania, under present conditions, the variety Sturmer appears to offer the greatest possibilities. By this method it is possible to hold this variety in a satisfactory condition by common storage methods for twenty weeks and possibly longer. It is available in quantity at the end of the season when low common storage temperatures are possible and is suitable for evaporating and canning.

(*b*) *At Stanthorpe.*—Routine work, such as growth measurements, spraying, fertilizing and pruning, has been carried out fully and occupies a large proportion of the working hours.

An interesting development during the year was the application of Wickens' method of pruning to young Jonathan and Granny Smith apple trees. This consists of leaving the leaders unpruned and training them into position by tying and staking ; pruning out inside growths and the lateral growths near the tips of the leaders, so as to allow the leading shoots to maintain their dominant positions. Secondary leaders are forced into growth at suitable positions by nicking the bark and wood above suitably placed buds. Although only tried this

season, it would appear that there are difficulties in the application of this method especially at Stanthorpe where a strong spring growth often does not materialize and the forcing of lateral growths is difficult. Buds along the leaders failed to shoot this season, even after three nickings, and most lateral growth appears on the southern sides of the leaders, leaving the sides facing the sun practically bare. This occurred even with Jonathan, which variety normally throws more laterals than Granny Smith. The same results have been observed in another orchard where in addition to these varieties, Stayman's Winesap was used.

One-year-old Williams pear trees are ready for planting as a stock experiment. These are on five vegetatively raised rootstocks, namely, Malling, and on seedling *P. Calleryana* stocks. Further studies have been made on the rooting systems of the Malling pear stocks and their compatibilities with commercial varieties of pears. A series of Delicious apple trees on locally-selected stocks, on Malling XII. and on their own roots, are ready for planting from the nursery.

(ii) *Citrus.*—Citrus investigations at the Griffith Research station and on the Murray River irrigation settlements have been continued.

(*a*) *Seed.*—This year seed was obtained from trees that had a reputation on the Murrumbidgee irrigation area and Murray River for good rootstocks, and grown along with seed from local trees which were used as controls for the types obtained from overseas. Two types from Norfolk Island were also grown. The seedlings raised from overseas seed were planted in nursery rows, and three of the types, Jamburi from India, Japaneshe Citrone from Malay, and the Californian rough lemon, were proving much more vigorous growers than most of our local types. These plants were killed by frost in May, but buds from them were set in other stocks before this occurred.

(*b*) *Root Cuttings.*—More blocks of old trees were located in the Murray settlements for next season's work. Fourteen rough lemon types, three sweet orange, and one Seville were used as sources of root cutting from outstanding trees on the Murrumbidgee irrigation area. The cuttings rooted in 1939 were planted in nursery rows. A very large range of vigour is evident in the growth of these rootlings, a Seville type being outstandingly vigorous. Some show a partial incompatibility with one or another of the two scions used, i.e., Valencia or navel orange.

(*c*) *Growth Studies.*—A survey method of assessing tree health has been in use on the Research Station plots since February, 1939, and the progressive deterioration in tree health that has taken place on all fields has been recorded. These records show that on the green manure field lucerne is the treatment which has had the most beneficial effect on tree health. Applications of ammonium sulphate on this field have improved tree health, but this has not happened where only artificial manures have been used. In that instance the application of superphosphate induces mottle leaf.

Weekly records have been continued in the root trench. It is evident that some are permanent roots which grow during the season, become dormant, and then resume growth the following year. These roots produce laterals and other roots which only appear to last a season. In the two seasons during which these roots have been observed, new root growth only took place from January to April, inclusive, new growth occurring in the spring. Water absorption by roots was taking place throughout most of the season and was rapid in the spring. This is indicated by the graphs of the changes recorded by the Rogers moisture meters which were installed at 6 inches, 11 inches, and 24 inches depth in February, 1940.

Sampling for horizontal and vertical distribution of roots in different soil types is being done in conjunction with the Farm Project Scheme being carried out at the Griffith Research Station. Sampling has been completed on a block of 22-year old navels on rough lemon stock growing on Banna Sand. The trees are in an unhealthy condition and water tables are sometimes within 2 feet of the surface. There were few roots below 50 centimetres and the greatest concentration of roots was at 10 to 30 centimetres. There were many more roots at the drip of the tree than in the centre of the bays where roots were sparse. A large proportion of the roots were dead, and the live roots were heavily infected with eelworms.

(*d*) *Inarching.*—Nine plots were established in 1939 in irrigation settlements from the Murrumbidgee area to Waikerie. They were designed to determine what improvement could be effected by inarching unhealthy trees. It has been found comparatively easy to establish the inarches but no beneficial effect has been observed as yet on the health of the trees. This season a trial was made of inarches inserted into single branches of trees on the Griffith Research Station in an attempt to get quicker results and better control.

8. *Drug Plants Investigations.*—At the time of preparation of this report a survey is in progress in coastal Queensland areas for the purpose of locating indigenous or naturalized plants which may be sources of certain drugs such as caffeine, ephedrine, cocaine, quinine substitute,

and of substances such as derris. Analyses of material are being made by the Departments of Pharmacology and Physiology of the Universities of Sydney and Melbourne, respectively. The present position with respect to the drugs and drug plants is briefly as follows :—

(i) *Hyoscine and Hyoscyamine.*—During the past six months hyoscine has been satisfactorily extracted from *Duboisia myoporoides* on a commercial basis by a local manufacturing company. Hyoscyamine has also been obtained in high concentration in *Duboisia myoporoides* from naturally occurring stands in certain localities in New South Wales. Supplies of naturally occuring *Duboisia* in Queensland and New South Wales are sufficient to meet our full requirements of both alkaloids for many years.

Small plots of *Atropa belladonna* were grown in several localities during the past season. Analyses of material are not yet to hand, but it is expected that the product will prove satisfactory. Adequate seed supplies of this plant have been harvested. Extensive areas of *Datura metel*, *D. stramonium*, *D. ferox*, and *D. tatula* occur in Victoria, New South Wales, and Queensland. Analyses have shown considerable variation in the alkaloid content of different species and strains and in material obtained from different localities. Selected strains have been cultivated at Canberra. There is no doubt that ample raw material is available to supply Australia's requirements. Small plots of *Hyoscyamus niger* have been cultivated, and seed supplies for more extensive plantings will be obtained from these plots next season.

(ii) *Glucosides of Digitalis.*—Plots of *Digitalis purpurea* were grown in various localities during the past season, and no difficulty was encountered in producing a satisfactory product. In one centre in Victoria, *D. purpurea* was produced on a satisfactory commercial basis. Plots of *D. lanata* have been established but samples have not yet been taken for analysis. It is expected that the plants will reach a stage suitable for sampling next season and that sufficient seed will be obtained from the present sowing to meet all requirements for future planting.

(iii) *Strychnine.*—A small number of seedlings of *Strychnos nuxvomica* have been raised during the past season and are growing at several centres in Queensland. It will be some years before the extraction of strychnine from these plants will be possible. A small plantation in the Kemp Welch River area in Papua is producing seed. Analyses of these seeds indicate a satisfactory content of alkaloids (1.36 per cent.). Analyses of the native species *Strychnos lucida* revealed the presence of brucine but not strychnine. Analysis of *S. arborea* and *S. psilosperma*, two other native species, are in hand.

(iv) *Ephedrine.*—Seedlings of *Ephedra sinica*, *E. gerardiana*, *E. nebrodensis*, and *E. intermedia* have been raised at several centres during the past season. These species are of Indian origin and are reported to contain ephedrine in appreciable quantities. The reported ephedrine content of *E. gerardiana* is higher than that of *E. sinica*. Our experience to date suggests that *E. gerardiana* is easier to cultivate than *E. sinica* and is of faster growth. . Attention is also being given to the possibility of locating alternative sources of supply in native or naturalized plants.

(v) *Emetine.*—Root cuttings are being propagated at South Johnstone in Queensland and native and naturalized plants of the *Rubiaceae* are being tested for the presence of emetine.

(vi) *Santonin and Filix-mas.*—From plants of *Artemisia maritima* raised at Canberra, chemical tests of flower heads are in progress. Plants of the fern *Filix-mas* are being raised from spores.

(vii) *Strophanthin and Ouabaine.*—Sufficient seedlings are being raised of *Strophanthus kombe* and *S. eminii* to provide essential Australian requirements of seed. It is not expected that the plants will reach the stage of seed production in less than five years. Some attention has been devoted to the question of obtaining strophanthin or a substitute glucoside from native and naturalized plants such as *Asclepias curassavica*, *Gomphocarpus fructicosus*, and *G. physocarpus*.

(viii) *Ergot.*—Extensive trials have been conducted by the Victorian and New South Wales Departments of Agriculture, with respect to ergot production, during the past season. Analyses from only two centres, viz., Werribee South and Canberra, have been completed, and the quality of the product exceeded *British Pharmacopœia* requirements.

(ix) *Quinine.*—Seedlings of *Cinchona succirubra*, *C. ledgeriana*, and *Cinchona* hybrid (*succirubra* and *ledgeriana*) have been raised in several localities in Queensland during the past season with the co-operation of the Queensland Department of Agriculture and Stock, the Forestry Sub-Department of Queensland, and the Plant Acclimatization Society of Queensland. It is proposed to lay down several 1-acre plots in the form of a forestry plantation as soon as the seedlings have grown sufficiently to plant in the field.

(x) *Opium and its Alkaloids.*—Sowings of several varieties of *Papaver somniferum* made last spring in different locailities demonstrated that this plant can be grown satisfactorily in Australia. The most suitable areas from the point of view of morphine production have not been definitely determined, but a reasonably accurate forecast can now be made in this connexion. Morphine production as manifest by the analysis of opium samples was variable but satisfactory.

Considerable progress has been made in evolving a satisfactory process for the extraction of morphine and codeine direct from the dried whole plant. Results have been sufficiently promising and conclusive to induce one manufacturing firm to decide to install a single unit pilot plant for this extraction.

9. *Potato Investigations.*—(i) *Survey.*—In 1937 a survey of the potato industry was authorized to be undertaken jointly by the Council and the Department of Commerce. The work was done in co-operation with the Departments of Agriculture of each of the States, and the Committee's report on the agricultural features of the industry was published as Pamphlet No. 106 in 1941. It deals with the climate and soils of potato-growing areas, agricultural methods, manures, rotations, sources and treatment of seed tubers, methods of cultivation, varieties, diseases and pests, certification schemes, and potato breeding. The average yield of potatoes per acre in Australia is very low ; this is due in part to diseases, especially those caused by viruses on which, since the survey was made, much work has been done.

(ii) *Potato Virus Diseases.*—Attention was paid during the 1940–41 season to virus X, one that is present in all the commoner Australian varieties, but does not cause very obvious symptoms. An experiment designed to test the effect of this virus on yield showed that it may cause reductions of between 20 and 30 per cent., so that if it were eliminated from the Australian crop, there should be a very large saving in the land, labour, and equipment needed to supply our requirements of potatoes. Attempts to obtain potatoes of the variety Up-to-Date (Factor) free from virus X and all other known viruses have been successful, and there is now a nuclear stock of this variety, which could be multiplied to supply seed for commercial growers. Attempts are to be made to find virus-free material of other common Australian varieties. Considerable progress has been made in separating different strains of virus X from the mixtures in which they are found in potatoes. A study is being made of the protection afforded against infection with severe strains of virus X by previous infection of potato plants with a very mild strain. Evidence has been obtained that this protection is not completely effective.

Considerable doubt has been thrown on the identity of a condition which has been known in New South Wales for some years as spindle tuber, and attributed to a virus. Measurements of tubers showed that the effect of the disease on tuber shape was similar to the effects of true spindle tuber (*see* Annual Report 1939–40), but in field trials and greenhouse transmission tests the disease has not been transferred from diseased to healthy plants. True spindle tuber is readily transmissible. Counts of aphides on potatoes were made at Canberra during the 1940–41 season, and are to be extended during the coming season. An officer of the Division of Economic Entomology has taken over much of this work.

10. *Other Investigations.*—(i) *Maize Diseases.*—Inoculation experiments at Orbost and Lindenow (Victoria) and at Canberra failed to reveal any consistent differences in the susceptibility of several Victorian strains of yellow dent maize to stalk or ear rot. An introduced hybrid white maize, said to be resistant to *Diplodia zeae*, appeared to be somewhat more resistant than yellow dents or a Victorian strain of Cornplanter, but is was doubtful whether it had any advantage over Hickory King. Artificial wound inoculation appeared to be of less value than natural infection for revealing differences in varietal resistance.

Trials of fungicidal dusts for the treatment of maize seed were made at Orbost, Lindenow, Bruthen, and Canberra. The dusts had no perceptible effect on germination or vigour of early growth except at Canberra, and then only when inferior or diseased seed was used. The relation of bacterial and fungal infection of the apical buds to a disease termed top or heart rot was investigated ; it was shown that other malformations or barren stalks may result from such infection. The percentage of barren plants appeared to be influenced much more by environment than by hereditary factors. " Multiple nubbins " were produced experimentally by the removal of the main ear shortly after pollination.

The possibility of growing green manure crops amongst maize plants in order to assist in maintaining soil fertility under continuous cropping was investigated at Orbost. The seed was broadcast amongst the maize just before the final cultivation at tasselling time. Of fourteen such crops, none gave satisfactory growth, with the possible exceptions of tick beans and vetches, though several made excellent growth when sown at the same time under normal conditions.

The percentage of Diplodia-rotted ears in crops at Maffra and Lindenow varied with the moisture-content of the soil during the growing period, and the previous cropping of the land. There was much more ear rot on dry ridges, or on old maize land, than in moister depressions or in maize following pasture. What was at first thought to be an exceptionally severe outbreak of root and basal stalk rot in some crops near Maffra was later ascribed to shortage of sub-soil moisture at tasselling, being confined to areas with a rich alluvial loam top soil but a very sandy sub-soil.

(ii) *Diseases of Pine Trees.*—During the winter of 1939, broadcast top-dressings of superphosphate ranging from 1 to 3 cwt. per acre were applied to large replicated plots in backward stands of pines, including many trees with " needle fusion ", in plantations or infertile sandy soils.

There was no consistent response in the 1939-40 season's growth. During the 1940-41 season, there was a definite response to superphosphate in some of the experiments. On plots treated with 1½ cwt. or more of superphosphate per acre, with or without borax, the average diameter of the trunk at breast-height increased by about 10 per cent. during 1940-41, while in untreated plots or those treated with borax alone, the increase was about 7.5 per cent. As compared with the previous season, there was an increase in the growth-rate of the phosphate-treated trees, and a decrease in that of the untreated trees.

There was also a much higher percentage of recovery from "needle fusion" in the phosphate-treated plots. This occurred in some of the borax-treated plots the first season after treatment, but these did not show any increase in growth-rate, and later reverted to their previous state. In some places the phosphate treatments had little or no effect, possibly due to insufficient rainfall since they were applied. Several water-culture experiments during the past two seasons demonstrated that boron is essential to the normal growth of seedlings of *Pinus radiata* and *P. taeda*.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—During the year 1940-41, the emphasis previously placed upon the various activities of the Division of Economic Entomology has had to be altered considerably. For several reasons, including military service and transference to other Divisions to carry out work of immediate national importance, the staff has been greatly reduced. At the same time it has been necessary to concentrate on investigations of immediate importance to the nation's war effort. Consequently, long range investigations, although admittedly of considerable importance, have had to be abandoned for the time being.

The most important entomological problem arising out of war-time conditions in Australia (apart from those concerned with human health and hygiene) is the protection of stored wheat from the attacks of insect pests, principally the species of small beetles known collectively as "weevils". The danger of these insects actively breeding in the wheat stocks was amply demonstrated during the last war, when shipping was disorganized and large quantities of grain had to be held in the country for extended periods. Although the problem was tackled vigorously in 1917 and 1918, and a good deal of experimentation undertaken, no completely satisfactory method of weevil control was evolved; and since that time conditions of storage have changed with the adoption, in three States, of bulk handling, a fact which complicates the problem considerably. At the request, and with the financial assistance, of the Australian Wheat Board, the Division has undertaken the investigation of the problem of wheat weevil control. The work was regarded as of great urgency (though the light crop of 1940 eased the storage situation), and, therefore, increasing numbers of the staff were diverted to the investigation. Ultimately all the members of the Termite Section, and an officer who had been carrying out chemical investigations on insecticides, were engaged in work directly or indirectly connected with the control of wheat-infesting insects. Close contact was also maintained with the entomologists in the Departments of Agriculture of the wheat-exporting States, and at the Waite Institute, who have also been giving their attention to certain aspects of the general problem.

2. *Insect Pests of Stored Wheat.*—(i) *General.*—In planning the investigations, every endeavour has been made to anticipate the various practical problems that are likely to arise, and to obtain the information necessary to give sound advice on how to deal with them. The question of applicability in practice has been kept in the foreground in all experiments dealing with methods of treatment to assist control; and the cost of materials, and their availability in the different States, have been checked. Where a material employed in a treatment has to be specially prepared for application, the advice of commercial firms has been often sought so as to ensure that the method of preparation employed in the tests could be duplicated on a large scale; and where possible the test samples have been prepared by commercial methods.

The problem has been tackled from all angles, and the work has involved investigation into direct control methods, preventive treatments, experiments with insecticides for use in cleaning up infested premises, and a study of the reactions of the insects to varying conditions of temperature and humidity, and of the moisture relations of wheat itself. Officers of the Division have visited all the mainland States to acquaint themselves with local conditions of handling and storage, and to carry out trials of treatment methods.

During the first part of the year, laboratory work on weevil control was concentrated chiefly on a study of mineral dusts, the protective value of which, when mixed with grain, has received considerable attention from investigators overseas. Gratifying results have been obtained from this line of research, and one or two effective non-silicious dusts, readily available in Australia, have been discovered. (Silicious materials are suspect on account of the health hazard involved in their use.) Milling tests with treated wheat have demonstrated that the dust is removed in the ordinary mill-cleaning process. Dust treatment, however, has certain disadvantages. For instance, it adversely affects the appearance and the free-running properties of the grain. For

this reason, the wheat-handling authorities in this country do not regard dust treatment with favour. Nevertheless, it provides a means of protecting wheat from weevil attack (which no other method of treating grain can offer), and as such it may yet prove of practical value, should the storage position in Australia remain difficult for a lengthy period. Satisfactory progress has also been made in the other lines of investigation in this field, although many of the problems proved much more complex than was first expected. This is well exemplified by the work on contact insecticides, which is described below.

(ii) *Studies of Wheat-infesting Insects.*—The three most important primary pests of wheat (i.e., those attacking whole grain) are two weevils of the genus *Calandra*, and the lesser grain borer *Rhizopertha dominica*. One of the former (the rice weevil, *C. oryzae*) has hitherto been the most serious pest of stored wheat in Australia, but there are indications that *R. dominica* may be a more serious danger under present-day conditions. The two factors that have the greatest influence on the speed of these insects' multiplication are temperature and humidity—the latter usually operating indirectly, through grain moisture contents. So great is the difference in breeding rate when these two factors, in combination, are favourable or unfavourable that, in practice, the physical condition of the stored grain probably overshadows in importance the degree of original contamination.

The optimum temperature for *Calandra oryzae* seems to lie between 80° and 90° F.; that for *C. granaria* being somewhat lower. Above 90° fertility drops to a marked extent. There has been no breeding by either species in the laboratory cultures maintained at 95° F. This temperature, however, appears to be optimum for *Rhizopertha dominica*, which multiplies very slowly at temperatures below 80° F. The upper temperature limit of breeding has not been determined for this insect, though it has been found that a temperature of 100° F. is less favorable than one of 95° F.

The results of several laboratory experiments indicate that *C. oryzae* is unable to multiply at a dangerous rate in wheat maintained at less than 10.5 per cent. moisture content. Above this figure, increase in grain moisture results in a relatively enormous increase in the multiplication rate. Both *C. granaria* and *R. dominica* are adapted to breed in grain with lower moisture than is *C. oryzae*, but in both the rate of breeding increases with increasing grain moisture up to the limits tested in the laboratory. These figures of temperature and grain moisture are of considerable importance in relation to the temperatures and moistures which wheat, stored in different ways and in different localities, attains in practice.

(iii) *Wheat Moisture Content and Atmospheric Humidity.*—The moisture contents at which wheat tends to come to equilibrium at different atmospheric humidities have been determined by laboratory experiment, using both hard and soft varieties of grain. Allowing for the slight variation between samples, and between different types of wheat, the equilibrium moisture contents (at 68° F.) in atmospheres with relative humidities of 30, 40, 50, 60 and 70 per cent., are respectively 9–9.5, 10, 11, 12, and 13.5–14 per cent. At a temperature of 86° F. the equilibrium moisture content for each relative humidity is about 0.5 per cent. lower than the figures just quoted. It might be mentioned that in a normal season most of the crop is harvested with less than 10.5 per cent. moisture in the wheat-exporting States, and that the mean annual relative humidity of Sydney, Melbourne, and Fremantle is 68 per cent. Experiments to determine the rate at which wheat can pick up moisture from, or lose it to, the atmosphere have shown that there is no significance between the rates of loss and gain, which in the exposed surface layers can be of the order of 1 per cent. per day.

(iv) *Fumigation.*—Although the Division does not possess the special equipment necessary for the accurate assessment of the relative toxicity of fumigants, a series of experiments, using simple apparatus, was carried out to determine the relative susceptibility to fumigants of the two species of *Calandra* and *Rhizopertha dominica*, since very little is known of the reaction of the last-mentioned insect to fumigants. The following "liquid" fumigants were used in these tests:—dichlor-ethyl-ether, chloropicrin, ethyl formate, ortho-dichlorbenzene, carbon bisulphide, ethylene dichloride, and carbon tetrachloride. The results obtained indicated that *Rhizopertha* is more susceptible to all these fumigants than are either of the *Calandra* species. Laboratory experiments have also been carried out to assess the fumigant effect of different tar-oil fractions, and also to determine the effect on *Calandra* of atmospheres containing varying concentrations of carbon dioxide.

Practical scale fumigation trials of infested wheat in concrete silos have been carried out. The first fumigant tested, methyl bromide (a heavy gas that is being used for commercial fumigation to an increasing extent in the United States of America), proved unsatisfactory. "Cyanogas G" (a crude form of granular calcium cyanide) was then tested, with a view to determining whether it could be used economically and effectively to treat wheat in open-topped silo bins. The results obtained were most encouraging, apparently complete control of *Rhizopertha*

dominica being obtained when using a dosage not much in excess of that recommended for closed-topped bins. Further tests are required, however, to determine the dosage required to effect control of *Calandra* infestations.

Experiments have been carried out, in a New South Wales silo containing heating wheat, to determine whether an infestation of the surface layers of bulk wheat (such as is characteristic of *Rhizopertha dominica* under certain commonly-occurring conditions) could be effectively controlled with carbon bisulphide. The results obtained indicated that this fumigant, applied with a sprinkler at the rate of 8 oz. (200 ml.) per square yard, effectively sterilized the grain to a depth of 12 inches, or of 18 inches if the surface were covered with a light tarpaulin.

(v) *Treatment with "Inert" Mineral Dusts.*—(The term "inert", though not strictly applicable to many of the dusts tested, is used to imply an absence of chemical toxicity). The first object of the work under this head has been to discover a safe, inexpensive, readily available mineral dust which will protect wheat from weevil infestation when mixed with the grain in a concentration not exceeding 1 per cent. by weight. Most of the mineral samples obtained for testing were pulverized by commercial grinding firms to pass through a 200 mesh-to-the-inch sieve. Certain imported dusts, such as the German "Naaki" (a finely ground crystalline silica) and two commercial products which British investigators have been studying, were included in the tests for purposes of comparison. Samples of any mineral which appeared to be suitable (on account of availability and colour) for the purpose in view were obtained, and a considerable number in all have been subjected to test. Those materials that showed promise in preliminary trials were subjected to further study. This involved the following experiments, most of which were replicated with wheat at different moisture contents and with each of the three chief pest insects: (1) to test the protective value of dusting, clean wheat was treated with varying concentrations of the dusts and weevils added, the count of live and dead insects being made at intervals up to about 3 weeks to determine the time-mortality curve; (2) wheat with different degrees of infestation (and containing immature stages, protected inside grains) was treated; (3) dusted wheat was infested at varying times (up to 8 weeks) after treatment; (4) dusted wheat, to which weevils had been added at weekly intervals, was incubated for sufficient time to permit two or more complete generations. In addition, the particle sizes and shapes of some of the dusts were studied, and the effectiveness of the different particle-size fractions (separated by means of an infrasizer) was determined; also the relative rates of moisture loss in dusted and undusted weevils was determined. The principal results of the various experiments carried out under this head can be summarized as follows: (*a*) *Calandra granaria*, *C. oryzae*, and *Rhizopertha dominica* differ somewhat in their reactions to dusts; (*b*) the efficacy of dusts decreases with increasing grain moisture content and atmospheric humidity; (*c*) samples of the same mineral from different deposits in general give similar results, though occasional variations (some marked) were met with; (*d*) dusted weevils lose moisture at a greater rate than undusted insects, a finding which confirms results obtained overseas indicating the efficacy of these "inert" dusts depends on a process of physical dehydration.

The most effective Australian dusts were found to be magnesite, a limonite with a high iron content, calcined diatomaceous earth, ferrigunous bauxite, and dolomite. Of the white, non-silicious minerals, magnesite is outstanding, and our experiments leave little doubt that a suitable magnesite, used at 0.5 per cent. concentration or even less, would effectively protect stored wheat from weevil attack in all but the most unfavorable climates. Moreover, the difference in the degree of infestation built up in dusted grain and in untreated controls indicates that some of the less effective dusts, e.g., dolomite, might well provide satisfactory protection in practice.

With a view to checking the results of the small-scale laboratory experiments, two trials of selected dusts, using in one instance full-sized (3 bushel) bags and in the other 50-lb. bags of wheat, have been set up near Sydney and at Toowomba with the co-operation of the entomologists of the Departments of Agriculture of New South Wales and Queensland, and of officers of the Wheat Board in the latter State. These tests are still running. In addition to the above-mentioned people, the Mines Departments of the several States have given material assistance in the work with mineral dusts. The Government Entomologist in Western Australia has furnished samples of dusts for tests, while the Lecturer in Entomology in the University of Sydney (Mr. A. R. Woodhill) has co-operated with the Division in certain of the laboratory studies.

(vi) *Stack Site and Shed Sterilization.*—Where wheat is still handled in bags, it has been amply demonstrated that the annually used stack sites and sheds constitute a dangerous source of contamination, and it is, therefore, important to be able to "sterilize" sheds and stack sites at country sidings if wheat held in them for some time is later to be moved to storage depots. An effective stack-site treatment, in addition to being cheap enough to apply on the very large scale that must be considered, should achieve the following objects:—(*a*) kill exposed weevils, and if possible those hiding in crannies, &c.; (*b*) kill, or prevent the successful emergence of, immature stages sheltering in the grains of spilled wheat, which is usually plentiful in stacking sites; and

(*c*) render spilled wheat unsuitable as a feeding and breeding ground for weevils. No single material or mixture adequately fulfilling all the above-mentioned requirements has yet been discovered, but considerable progress has been made in our attempts to develop a satisfactory method of treatment, and work under this head is being actively pursued. The contact-killing properties of a liquid are assessed in the laboratory by a dip technique. Dipping grain containing immature stages of the insects, followed by incubation to determine emergence, is used to assess the effectiveness of a material under (*b*) above. To assess its effectiveness under heading (*c*), clean grain is dipped in the liquid ; the grain is then dried, weevils are added after varying intervals, and the mortality among them is determined. An effective contact kill of adult insects is relatively easy to obtain, and, therefore, the problem largely becomes one of discovering a means of augmenting the properties of a contact insecticide in such a way as to produce the desired additional effects. If this is to be achieved by admixture with other substances, the added component must not be too expensive, and must leave the contact toxicity of the mixture unimpaired.

The materials that can be considered for stack-site sterilization fall naturally into two classes according to their cost. Carbon bisulphide, naphthalene, and dichlorbenzene are relatively expensive ; petroleum oil fractions and tar oil fractions are relatively cheap ; and work is, therefore, now being concentrated chiefly on the latter. These substances have to be used in the form of emulsions, a fact which complicates the problem considerably, for (as is well known) the toxicity of oil emulsions is very largely dependent on their droplet size and stability. In order to clear up, particularly, the problem of the use of petroleum and tar oil fractions for use as contact insecticides against weevils, it has been necessary to make a fairly detailed study of their practical emulsification, and for help and advice in this connexion the Division is indebted to the technical staff of the Vacuum Oil Company in Melbourne.

A number of petroleum oil fractions, emulsified in different ways, and a long series of different creosotes and tar distillation products have been tested as contact agents against *C. granaria*, *C. oryzae*, and *R. dominica*. In general it has been found that high-boiling range creosotes are good contact agents, while low boiling range products are usually poor or ineffective. None of the straight petroleum or tar oil emulsions have proved particularly effective for preventing breeding in wheat.

For killing developmental stages in wheat, of the many emulsions tested only orthodichlorbenzene and dichlorether, or mixtures of these with creosotes and oils, have shown consistently good results. For poisoning grain to prevent weevil activity and breeding, certain arsenicals have given the best results, but some creosote and oil emulsions and emulsions of mixtures of creosotes or oils with the above-mentioned " heavy " fumigants have proved fairly effective.

A series of experiments in which weevils and infested wheat were buried at different depths in trays of sand, has been carried out to discover a suitable method of treating wheat-shed floors when these are of loose earth in which infested grain may be buried. The results obtained indicated that emulsions of carbon bisulphide or orthodichlorbenzene, or crude naphthalene (a solid), might be used with good effect. A trial-demonstration of the carbon bisulphide treatment was carried out in an infested shed in South Australia.

(vii) *Miscellaneous.*—In addition to the main lines of investigation discussed under the above heads, a number of experiments and observations have been undertaken from time to time, in the laboratory and in the field, to clear up special points that required elucidation. Among these may be mentioned a study of the effect of " turning " on the temperature of bulk wheat, an assessment of the destructive powers of the main primary grain pests, and the effect of different population densities on their breeding rate.

One of the Division's officers visited the Stored Products Laboratory at Slough, England, and studied the work on wheat pests in progress there, particular attention being given to the utilization of inert dusts against wheat weevils. A report on the methods employed by this laboratory in their wheat weevil work has been made to the Council.

3. *Insect Control of Noxious Weeds.*—During the past year, overseas investigations of possible insect enemies of noxious weeds have been terminated, for, under present conditions, overseas work could not satisfactorily be continued. Moreover, the task of sending live insects to Australia became almost impossible because of the irregularity and uncertainty of air and shipping services. The officers engaged in this work have either returned to Australia or taken up military duties.

(i) *St. John's Wort* (*Hypericum perforatum*).—The development of hostilities in France led to the closure of the field station in the Var early in June, 1940. It had been shown that *Agrilus hyperici* amd *Chrysolina gemellata* were the dominant enemies of St. John's wort in the Var, and

since large consignments of *Agrilus* were sent to Australia early in 1940 and stocks of *C. gemellata* already existed at Canberra, the enforced closure of the station has not seriously affected the work on this problem.

Chrysolina hyperici has spread considerably in the Bright district (Victoria) in the past year. It now occurs in large numbers over a distance of 2 miles along the Ovens Valley and has caused the destruction of the weed in some places. The liberation in 1939 of adults collected at Bright has resulted in the establishment of this insect at four new points in the Bright district and at two areas near Tumbarumba (New South Wales). In 1940, 34,000 adults collected at Bright were liberated at Myrtleford, Harrietville, Tawonga, and Dargo in Victoria, and 18,000 adults in two areas at Mudgee, New South Wales. There is already evidence that the beetle is established at Harrietville, but information from the other districts is not yet available.

In Baker's Gully, Bright, where small numbers of *Agrilus hyperici* were liberated in 1939 at three points, recoveries were made at each and the first Australian-bred specimens emerged in the field in November and December, 1940. From infested *Hypericum* roots sent from France early in 1940, 5,875 *Agrilus* adults were liberated, 4,825 at Mudgee (New South Wales), and 1,050 at Baker's Gully. Since fresh supplies cannot be obtained from Europe, a special effort was made to increase the population at Baker's Gully. Pairs of adults were isolated on sleeved plants and removed to fresh plants when oviposition had been secured. It was estimated that some 1,200 fertile eggs were laid on the experimental plot in this way.

Liberations of *Chrysolina gemellata* (referred to in previous reports as *C. geminata*) in Victoria have not resulted in the establishment of this insect. Further stocks are being bred at Canberra for liberation at Mudgee (New South Wales) which is probably a more suitable area for this beetle.

(ii) *Lantana* (*Lantana camara*).—Recently a survey was carried out by one of the Council's officers in lantana-infested areas between Townsville and Cairns, North Queensland, to ascertain the extent of the attack by *Teleonemia scrupulosa* on its host plant. The survey was also continued in the Rockhampton district. In general, it may be said that in coastal areas north from Townsville, the position is very satisfactory and continues to improve. In more southern areas, although established at a number of points, it is doubtful if the bugs will do such effective work on account of adverse climatic factors. It has been stated that the destruction caused by *Teleonemia* in north Queensland is far greater than anything witnessed overseas. Experimental colonies of *Teleonemia* have been liberated in forest areas in northern New South Wales, and, so far, the bugs appear to be establishing themselves, although rather slowly. It is, as yet, much too early to ascertain whether *Teleonemia* can survive and exercise any satisfactory degree of control over lantana so far south.

(iii) *Noogoora Burr* (*Xanthium pungens*).—All overseas investigations on the control of this weed by beneficial insects have now been terminated. During the period under review, extensive surveys were made throughout the Central and United Provinces of India, and a careful study was made of insects which attack *Xanthium*. Exploratory work was also extended to Assam. Apart from the Cerambycid beetle, *Nupserha antennata*, the only other insect of any importance which was found throughout those areas examined was a Noctuid, *Eublemma rivula*, the larvae of which attack the fruits of *Xanthium*. These are the only two species of insects considered to exercise any degree of control over *Xanthium* in India, and neither are considered at all suitable for introduction into Australia.

As a result of the liberations made in burr-infested areas in southern Queensland, during the past few years, the burr seed-fly *Euaresta aequalis* has been found to breed in the field in small numbers where liberations had previously been made. It seems unlikely, however, that the fly will succeed in controlling the burr to any appreciable extent. The burr crop is often very erratic throughout southern Queensland, so that the fly is likely to have considerable difficulty in adapting its life cycle to the fruiting of its host plant, and maintaining a suitable infestation. Sufficiently large numbers of *Euaresta* have now been liberated in Queensland to show whether this fly is capable of establishing itself in sufficient numbers to exercise any degree of control over its host plant.

(iv) *Nut Grass* (*Cyperus rotundus*).—The work of insect enemies of nut grass was studied by one of the Council's officers in Hawaii, and it was concluded that their effect on the spread of the weed was negligible. However, this may have been due to the fact that both the weevil *Athesapeuta cyperi* and the moth *Bactra truculenta* were heavily parasitized. About 4,000 insect infested plants were forwarded to Canberra. These insects will be tested for their effects on useful species of *Cyperus*, such as *C. victoriensis* and *C. retzii* before their liberation is considered.

(v) *Mexican Poppy* (*Argemone mexicana*).—A survey of the insects attacking this plant in Texas showed that of ten insects associated with it, only two were of any importance. The weevil, *Conotrachelus leucophaetus*, fed on the roots and caused a good deal of damage. It will also breed on *Amaranthus*. The stem boring beetle, *Languria laeta*, was plentiful but did little damage.

(vi) *Mint Weed* (*Salvia reflexa*).—This weed was also studied in Texas where it is particularly dense in certain parts. It is not eaten by stock, and only one insect of any importance was found attacking it. This was a beetle, *Mordellistena* sp., which destroys the seeds by killing the flowering spikes.

4. *Sheep Blow-fly.*—Owing to diversion of staff, attention has been restricted more to the purely entomological side of the problem than in previous years. Considerable progress has been made in three fields, namely, the compounding of two useful dressings, the study of repellents, and an investigation of the breeding ground of *Lucilia cuprina*, which has already been shown to cause 90 per cent. or more of strikes in Canberra.

(i) *Dressings.*—The boric acid, tar oil, bentonite dressing mentioned in last year's report has been modified somewhat to reduce the cost of ingredients. This modified dressing is called B.T.B. 15 after its main constituents and the concentration of boric acid present. Its composition is :—boric acid 15.0 per cent., bentonite, 3.0 per cent., tar oil, 2.0 per cent., wetting agent, 0.5 per cent., water, 79.5 per cent.

The outstanding features of this dressing are cheapness, rapid penetration into the fleece, stability and absence of irritation. To reduce freight costs, the dry components can be supplied ready mixed to the grazier who can prepare the dressing by gradually adding water and mixing to a uniform suspension before incorporating the tar oil.

The dressing was compared under insectary conditions with seven other dressings, some previously recommended in official reports, and the remainder promising proprietary products. Either artificially produced or natural crutch strikes were used. These were dressed and exposed to a relatively dense population of *L. cuprina* under highly favorable conditions of temperature and humidity. The incidence of re-strike (i.e., the development of fresh larvae on the dressed area before it had healed) was noted, as also penetration, contact toxicity, and repellency. B.T.B. 15 compared very favorably with C.B.E. (Camphor-Boracic-Emulsion) and B.T.B. 30 (containing 30 per cent. onstead of 15 per cent. boric acid), and these three dressings proved to be far superior to the remaining five. B.T.B. did not deter *L. cuprina* from laying eggs on the dressed area, but prevented re-strike very effectively. This may yet prove an important feature of this dressing, as the dressed sheep act as poison baits and destroy egg-laying females and their off-spring. Field trials, mentioned elsewhere, have confirmed the efficacy of B.T.B. 15.

(ii) *Repellents.*—The study of essential oils as repellents has been continued. As an attractant, cotton wool plugs soaked in a solution of indole and ammonium carbonate were tied into the fleece. Repellents were applied as 10 per cent. solutions in liquid paraffin with paraffin alone as control. Leaving about 1 inch of dry fleece around the plug, a ring of repellent or paraffin about ½ inch wide was painted on the fleece and the number of egg batches subsequently laid around each plug counted.

Java citronella oil is not as effective a repellent as Ceylon citronella oil, and none of the eight constituents of Ceylon oil so far tested has proved equal to it in repellency. Furthermore, three out of four fractions into which the Ceylon oil was divided by fractional distillation have also proved less effective. The fourth, although no more effective than the whole oil, is being subjected to further examination.

Camphor oil also proved considerably less repellent than Ceylon citronella.

Eight Australian essential oils were tested. Of these, three samples of eucalyptus oil from various sources exerted no repellent effect at all and the most promising oils proved to be zieria and huon pine.

(iii) *Carrion Studies.*—(*a*) The relative importance of live sheep and carrion as breeding grounds for *L. cuprina* has been investigated. Sheep carcasses were exposed, at monthly or half-monthly intervals throughout the year, in large maggot-proof trays, and the flies produced were counted. Only six out of eighteen carcasses produced any *L. cuprina* and the maximum number from any of these was 45 adults. During a further series of exposures the effect of predators and parasites was eliminated, but less than a thousand *L. cuprina* were produced by any one carcass. Trapping records showed that the *L. cuprina* population was ten times higher than usual, a fact confirmed by the high incidence of the strike in the field, so that the season was a favorable one for the fly. Amongst other factors, high carcass temperature (between 100° and 115° F.), produced by intense larval activity, was considered to be responsible for the small number of primary flies produced.

In contradistinction to the figures from carcasses, a medium to large strike has been shown to produce a thousand or more *L. cuprina*, and in a normal season there are undoubtedly more strikes than carcasses present in the field.

(*b*) Further work on the prevention of flies breeding in baits showed that borax sprinkled over the surface was completely effective in preventing larval development. This treatment may

reduce slightly the attractiveness of the baits, but prolongs the catching period. Borax treatment renders the bait poisonous also to the adult fly, although death may not occur for 40 hours after feeding.

(iv) *Physiological Studies.*—(*a*) *Ammonia Production.*—The mechanism of ammonia production by *L. cuprina* maggots was investigated. The amount of ammonia produced increases during larval growth and is greatest some time after the larvae reach full size. Moreover, ammonia continues to be excreted for some days after the cessation of growth. The amount produced per 100 larvae decreases with increase in population density, and with improvement in the nutritive properties of the medium. Microchemical studies of the distribution of ammonia in the organs and tissues of the larvae have shown that ammonia produced in the middle segment of the midgut is absorbed into the haemocoele whence it passes to the Malpighian tubes and is delivered into the hindgut. During passage along the hindgut, water is re-absorbed into the body cavity, and the ammonia solution is thereby concentrated before excretion, reaching a ratio of 0.5 per cent. in the posterior segment.

Ammonia appears to be produced by hydrolytic deamination of adenosine and, to some extent, of guanine and of higher polypeptides. It is inhibited by salts of iron and copper, also by sodium sulphide, iodoacetic acid, and boric acid. Boric acid inhibition of this important enzyme system may explain its larvicidal action on *Lucilia cuprina*. Other well-known larvicides, such as nicotine, phenothiazine, and the arsenicals, are without effect on deaminase.

Uric acid, which is produced in only small amount by the larvae, resides chiefly in the skeletal muscle, in the cuticle, and in the fat body.

Preliminary observations on the composition of the white granular material in the distal segment of the Malpighian tubes suggest that this consists largely of phosphates of magnesium and calcium.

(*b*) *Cuticular Penetration.*—Preliminary investigations were carried out to evolve a method for measuring the rate of penetration of substances through insect cuticle and the effect thereon of wetting agents. Cuticular sacs were obtained by removing the haemocoele contents of fully grown larvae. These sacs were then filled with pH indicators or spot test reagents and the ends sealed. Time for penetration after immersion in various solutions could be determined by colour changes in the solutions filling the larval sacs. Copper and barium ions did not penetrate the cuticle for at least a week and of the alkalis tested NaOH and KOH proved most effective.

(v) *Toxicity Studies.*—The contact toxicity of a number of dressings and also of various essential oils (including various eucalyptus oils) was studied. The results for 10 minutes' immersion at 25° C. did not show a high mortality, and further tests showed that most of the fully-grown larvae leaving a recently dressed strike were able to develop into adult flies.

Using the contact toxicity technique, it was shown that 0.4 per cent. arsenious oxide, with or without wetting agents, was completely non-toxic to prepupae when immersed for 30 minutes at 23° C.

Application of the previously described rate-of-mortality technique for the measure of stomach toxicity (Coun. Sci. Ind. Res. Pamphlet No. 101) has shown that *aa'* dipyridyl is almost as toxic as nicotine, to which it is structually related. Dinitro-o-cyclohexyl-phenol and proflavine are slightly toxic, and sulphanilamide, sodium diethyldithiocarbamate, quinhydrone, and iodo-acetic acid are non-toxic at a concentration of 0.2 per cent. in the enriched medium.

5. *Buffalo-fly* (*Lyperosia exigua*).—Further overseas investigations confirmed the belief already expressed that the dung fly, *Scatophaga stercoraria*, is unlikely to be of value as an enemy of the buffalo-fly in Australia.

6. *The Bush-fly.*—The bush-fly which commonly occurs during the warmer months is *Musca* (*Biomyia*) *vetustissima*. The breeding habitat is not known, and only isolated individuals have been bred from dung or carrion. A number of baits were tested and the most effective proved to be liver in the later stages of decomposition.

7. *Cattle Tick.*—The investigation of this pest was undertaken following representations made by the Cattle Tick Control Commission, which body has experienced unexpected difficulty in eradicating the cattle tick in certain areas in northern New South Wales. Accommodation has kindly been provided for this investigation by Professor Seddon at the School of Veterinary Science, Yeerongpilly, Queensland. The main object is to study the bionomics of the cattle tick, *Boophilus annulatus australis*, with special reference to the effect of temperature and humidity on the life cycle of the non-parasitic stages. Enquiries are also being made into the use of adjuvants in cattle dipping fluids.

Preliminary investigations reveal that the nonparasitic stages are very sensitive to humidity changes. It would seem that the number of eggs deposited and the percentage emergence from these eggs increases as the humidity increases. No emergence from eggs held at 70 per cent. relative humidity and a constant temperature of 21.5° C. has occurred up to date. The

developmental zero is still unknown, but it appears to be around 15° or 16° C. This is rather high and implies long incubation periods during the cooler months of the year. It has been observed that replete females are very difficult to wet with arsenical dips. Different parts of the body have been painted with sodium arsenite and soap, and it would seem that absorption takes place quite readily through the back. The value of a wetter is readily demonstrated by painting with sodium arsenite alone and then with soap and sodium arsenite. In the latter case, a 100 per cent. mortality is the rule in 24 hours, whereas some ticks will live two or three days when sodium arsenite alone is used.

8. *Australian Plague Locust* (*Chortoicetes terminifera*).—(i) *General.*—Work has been continued along the various lines described in the last report. By the kindness of Mr. E. I. Body, Bundemar Station (Trangie) has again been placed at the disposal of the Division for intensive study of the ecology of *Chortoicetes terminifera* in one of its chief outbreak areas. Results of increasing interest are emerging from this work. The co-operation of the States concerned in the New South Wales and Queensland Locust Information Services has continued to provide detailed information on current locust outbreaks and this has been analysed at Canberra as in previous years. The monthly forecasts of locust developments in New South Wales, which are based on the results of this analysis, have improved both in scope and accuracy. Laboratory work on the mortality and rate of development of hoppers of *Chortoicetes*, at various temperatures and humidities, is steadily giving further insight into the reasons why certain types of habitat and weather are favorable to the species, while others are unfavorable.

(ii) *Analysis of Recent Outbreaks of Chortiocetes.*—An analyses of the outbreak of 1939–40 has in general confirmed the conclusions regarding favorable and unfavorable climatic conditions which were reached from a study of the outbreaks of 1937–39, and which were detailed in last year's Report, and has also given added information on the outbreak areas of Queensland. Judged by the number of swarms recorded, the outbreak of 1939–40 in New South Wales was about twice as severe as that of 1938–39 but only one-third as severe as that of 1937–38.

The outbreak of 1940–41 was confined to the spring months (October-November) and to the north-eastern part of the New South Wales infestation area. The hoppers were subjected to severe drought conditions from the time of hatching, and mortality was high ; thus the resulting fliers were not in swarm formation, and the outbreak came to an end. The period December to June was the first since 1932 in which New South Wales has been free from both swarms and egg-beds. Following the rains of December, 1940, a second generation hatched in scattered (non-swarming) formation, mainly in the outbreak areas. This generation suffered heavy mortality, particularly in the outbreak areas of Queensland and north-eastern New South Wales as a result of the flood rains of January, 1941. However, sufficient numbers reached the adult stage to produce densities of one locust per four yards in places. These adults have laid eggs which, for the most part, are still unhatched, and which may lead to the first stages of swarm-formation next season.

(iii) *Monthly Forecasts of the Locust Position.*—A monthly statement of the locust position in New South Wales, accompanied by a map, and a forecast for the two succeeding months, has been issued to a limited number of interested persons since December, 1939. The statements indicate the distribution and approximate density of the infestation, the stage of development reached, and the distribution of weather conditions favorable to multiplication. In the absence of swarms, they also give what information is available (from field trips, and from the Trangie field-station) regarding the population in the various outbreak areas. The forecasts discuss the probable distribution, density, and stage of development of the infestation during the succeeding two months, and pay particular attention to the possibility of swarms developing in the outbreak areas.

(iv) *Laboratory Work.*—Cultures of *Chortoicetes* have been reared from hatching to death at constant temperatures of 80° F., 90° F., and 100° F., and at relative humidities ranging from 10 to 100 per cent. Records have been kept of the period required for development of the hoppers and for sexual maturation of the adults ; of the number of instars, and the length of each ; of the mortality in each stage ; of longevity ; and of colouration. Unfortunately, with the equipment available until recently, it has not been possible to separate the effects of the relative humidity of the air from those of the water content of the food. Bearing in mind this limitation, which is perhaps of great importance from the practical point of view, the following conclusions can already be drawn : (*a*) The length of the hopper stage, the number of instars, and the length of each stadium, are all least at the higher temperatures and humidities, and greatest at low temperatures and low humidities ; (*b*) Males normally pass through fewer instars than females ; (*c*) At favorable humidities, mortality does not vary widely at the three temperatures used, but is high at both very low and very high humidities ; (*d*) The colouration of both hoppers and adults is darker at low than at high temperatures. At 90° F. and 80° F. a progressive darkening takes place with age, particularly on the under-surface, but at 100° F.

the colouration remains pale, or even becomes paler. Green individuals did not appear under any of the conditions used. Individuals reared in groups of three in a small cage are much darker than those reared singly, indicating a development in the direction of phase *gregaria*.

(v) *Ecology of the Outbreak Areas.*—The study of the ecology of outbreak areas of *Chortoicetes* is being continued at the Trangie field station, and by means of periodical field trips in New South Wales and southern Queensland. Conclusions reached in the analysis of the outbreaks of 1937 have been used to compare the relative climatic favorability of the various outbreak areas.

It has been found that practically all the outbreak areas are located in the climatic zones in which the " normal " season has no month too wet, and not more than three successive months too dry, for multiplication of *Chortoicetes*, and in which two or more generations per annum can be passed through without high mortality. Within this climatic zone, the location of the outbreak areas is determined by the distribution of the " mixed soil " country which has been described in previous reports. Both climate and topography must be favorable before an outbreak area can be constituted. The essential characteristics of the " mixed " country is that it provides, in close proximity to each other, areas suitable for oviposition (oviposition sites), and areas in which the active stages can be certain of finding food and shelter during dry periods (concentration zones). The characteristics of these two types of habitat are now known in considerable detail. Oviposition sites include a considerable proportion of bare, compact soil, which, in the more favorable sites, is distributed in large patches separated by low vegetation (up to 6 inches high). Under conditions of normal grazing, such sites are always to be found in the major outbreak areas, though in some of the minor ones in northern New South Wales and Queensland they disappear in good seasons. Concentration zones are usually located in slight depressions on heavy soils, and are characterized by a patchy distribution of " shelter " vegetation, 1 to 3 feet high, and exposed areas, either bare ground or low vegetation only a few inches high. Another important characteristic is a persistence of green feed when the surrounding country has dried out. Concentration zones may become unfavorable during severe droughts, and sometimes in seasons of heavy rainfall, when too much vegetation grows in the " exposed areas ". To and fro migration of the non-swarming population takes place between the oviposition sites and concentration zones.

Where oviposition sites and concentration zones are situated immediately adjacent to one another, or where they coincide owing to the presence of bare ground amongst shelter vegetation, conditions particularly favorable for breeding are produced, and the resulting complex is known as an outbreak centre. Each outbreak area may be regarded as consisting of numerous outbreak centres separated by less favorable country. A number of outbreak centres have already been mapped in outbreak areas 1 and 2. Roads, with their associated table-drains, and paddock tracks, have been found to be important in creating the outbreak-centre environment.

Ibis have been found to exercise an important control on non-swarming populations. Other predators and parasites have so far shown little effect. The optimum black-bulb temperature for adults and late nymphs is of the order of 40° C. to 44° C. Locusts in the field adjust their position in relation to sun, shade, wind, &c., so that they experience temperatures as near as possible to this range. Under the conditions of last season, 40 to 100 eggs hatched per female of the preceding generation, an average of 52 eggs being laid per pod. Sexual maturation is related to the availability of green feed, and may require from two to twelve weeks. The lowest value for soil moisture at which egg-development can be completed is about 4 per cent. This is approximately a third of the wilting coefficient for the same soil.

9. *Red-legged Earth Mite* (*Halotydeus destructor*).—The aim of one important section of this investigation during the past few seasons has been to measure the reduction in yield caused by earth mite attack on subterranean clover pastures, and thus to obtain some estimate of the expenditure permissible on control measures. The cumulative effect over two seasons of earth mite attack on a subterranean clover pasture at Katanning (Western Australia), has proved to be quite pronounced. During 1940, plots which had been kept free of mites since their establishment in 1939 showed a very vigorous growth of clover in spite of the drought, whereas on plots subject to mite attack the foliage yield of the clover was reduced by one-half or two-thirds, according to whether the mite population was the natural one, or artificially increased for the purpose of the experiment. Similar great reductions in seed-yield also resulted from mite attack. There is much evidence from general observation to show that mite damage is most serious under drought conditions, and during the 1940 season the dry conditions undoubtedly increased the effect of the attack on the plants.

Although this experiment has definitely established the importance of the earth mite as a clover pest in the Katanning area, it must be remembered that the effect of the mite on such

other plants in the pastures as grasses, *Erodium* species, and caveweed (*Cryptostemma calendulaceum*) is of little importance, so that a reduction of the clover to the extent mentioned does not necessarily mean a corresponding reduction in total pasture yield.

A method has been developed for small-scale field testing of insecticides against the earth mite in which small pasture plots are employed, isolated with creosote to restrict movement of the mites. Population measurements are made by collecting and counting the mites occurring on a number of small areas marked off on each plot with metal enclosures. After the application of the treatments the population is re-measured, and information thus obtained of the effectiveness of the treatment against the earth mite. Among the substances tested during 1940 were most of those hitherto recommended for use against the mite. Several of the trials failed on account of the drought conditions, but some useful results were obtained. "DN dust", containing the synthetic organic compound dinitro-o-cyclohexylphenol, gave excellent results under the conditions of the experiment. A mixture of tobacco dust, slake-lime, and kerosene also gave good results. Exploiting the tendency of the mites to suck up sweet solutions, excellent control was obtained by sprinkling on the ground chaff moistened with a solution of cane sugar and sodium fluoride. Such a stomach-poisoning method is rarely possible against mites. Further advances have been made in the knowledge of the biology of the mites. The number of instars has been definitely established as five. Much interesting work has been done on the aestivating eggs of the mites, but it appears that it will not be possible to attack the mite at this stage of its life cycle in any way. A considerable increase in fertility of mites has been shown to result from their feeding on flowers of capeweed, a plant which has long been suspected of increasing the severity of mite attack.

10. *Insecticides.*—Studies of insecticides have been directed mainly towards the control of wheat weevils, since the present necessity for storing wheat, either bagged or in bulk, on sites previously used and carrying a weevil population, has raised the problem of the materials to be used for cleaning floors and dunnage before uninfested wheat is stacked. The question has not arisen as a major problem in normal times or in other countries, as wheat and silos can usually be treated by fumigation when storage for long periods is required. The details of the work are covered in the account of the wheat weevil investigations.

In last year's report on the codling moth it was stated that, arising from the investigation of nicotine insecticides, a study had been made on certain solubility relationships of nicotine. As a result of this work the development section of an Australian chemical firm has successfully made pilot plant trials of the salting-out process as part of their method for preparing nicotine commercially.

11. *Oriental Peach Moth* (*Cydia molesta*).—In the Goulburn Valley the moth population during the season 1940–41 was the lowest recorded since the investigation began. The abundance of the insect increased until the end of November, decreased in December and January, and increased to another small peak in February. The attack on peach twigs was the lightest it had been for two seasons and some young orchards almost entirely escaped attack. Fruit infestation was higher than in recent seasons (15 per cent.) and there was a sudden increase in attack on late peaches following heavy summer rains, when individual losses as great as 30 per cent. were recorded. In the small districts previously reported to be infested in the Murrumbidgee irrigation areas, no infested shoots were found and no moths were taken in lures at any time during the season.

An extensive survey of the peach-growing district was made, during the season, to see where the introduced parasite, *Macrocentrus ancylivorus*, had become established and whether it was spreading naturally. As a result of the survey, one parasite only was recovered from a collection made early in the spring, at a locality where parasites had been released during the past five years. The results of the survey are most disappointing, for they seem to indicate that conditions in the Goulburn Valley are unfavorable for *Macrocentrus*. The warm autumns may cause emergence of the parasite at a time when no Oriental Peach Moth larvae are available for parasitism. It is possible, however, that the parasite may be breeding in some orchards apart from those points where colonies have been released and where the 1940-41 collections were made.

12. *Banana Stem Borer* (*Cosmopolites sordida*).—At the request of the Queensland Department of Agriculture and Stock, consignments of the predatory beetle, *Dactylosternum hydrophylloides*, were introduced in 1938 and 1939 from the Federated Malay States to attack the banana stem borer. Liberations were made by officers of the Queensland Department, and a colony was quickly established and increased rapidly in numbers. From this colony the beetles have been distributed to other banana-growing areas.

13. *Pea Weevil* (*Brachus pisorum*).—Unfortunately, with the collapse of France, our officer was compelled to leave the Var district before further shipments of the parasitic wasp, *Triaspis thoracicus*, were ready to send to Australia.

14. *Cabbage Butterfly* (*Pieris rapae*).—Since its accidental introduction into Victoria during the past few years, this pest has spread throughout a large area in eastern Victoria and south-eastern New South Wales. In February, 1941, it was first recorded from the Australian Capital Territory, and, about the same time, from the vicinity of Sydney. Throughout the areas which it now occupies, the attacks of its larvae have resulted in considerable losses to cabbage and related Cruciferous crops.

The parasites of this butterfly have been studied in detail in Europe. Arrangements have been made for a similar study in North America, and for the introduction into Australia of certain parasites already known to be promising.

15. *Insect Vectors of Plant Virus Diseases.*—The increasing importance of plant virus diseases and the losses they cause to crops has necessitated more intensive study of the relationship existing between the viruses and their insect vectors. As it is mainly by means of insects that the diseases are spread from plant to plant in the field, it is essential that there should be a thorough knowledge of the life history, habits, distribution, host preferences, &c., of the vectors before any method of control can be evolved. During 1940–41 such studies were begun on a brown jassid, *Thamnotettix argentata*, a known vector of yellow dwarf disease of tobacco, and on two species of aphis, *Myzus persicae* and *Macrosiphum gei*, responsible for the transmission of leaf roll and viruses A and Y of potato.

16. *Termite* (*White Ant*) *Investigations.*—Tests that were in progress at the beginning of the year were carried through to completion. Thereafter no new work in this field was initiated. The activities of those of the Divisional staff who had been concerned with termite investigations (apart from taxonomic studies) were then diverted to research in connexion with the control of stored wheat pests.

The systematic revision of the Australian termites was completed during the year, and the monograph embodying the results of this investigation is now ready for publication.

17. *Beneficial Insects Sent Overseas.*—Attempts during 1939 to introduce the Lantana bug, *Teleonemia scrupulosa*, into India were unsuccessful. A further attempt proved successful during the past year, when a consignment sent by air reached its destination in satisfactory condition.

18. *Systematic and General Entomology.*—During the year, the Museum collection has been increased by the addition of several hundred specimens, from miscellaneous sources. The material included a small collection of stored products pests comprising 122 specimens, representative of 31 different species. These were mainly pests of wheat, and were obtained from the Stores Products Research Laboratory, at Slough, England. As in other years, numbers of insects have been identified for individual workers and institutions in Australia and overseas. In addition, advice or practical assistance has been given in response to numerous inquiries.

IV. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. *General.*—Progress has been made in all branches of the work of the Division of Animal Health and Nutrition, although this has been somewhat restricted by war conditions, especially through depletion of staff due to military service.

There has been no extension of the field of work of the Division which has been carried out as in the past at the three main centres in Sydney, Melbourne, and Adelaide, as well as at field stations at Cunnamulla (Queensland), Badgery's Creek (New South Wales), and Werribee (Victoria). Co-operative work with the State Departments of Agriculture was continued. Co-operation with the Division of Economic Entomology and with the Division of Plant Industry has been maintained as usual through the Veterinary Entomological Committee and the Inter-divisional Committee for Agrostology, respectively. The secretarial work for the Committee on Animal Production was carried out as previously.

The work of the Division has been greatly facilitated by the continued generous financial assistance of the Australian Wool Board, the Australian Cattle Research Association, the George Aitken Pastoral Research Trust, and the Queensland Government.

2. *Animal Health Research Laboratory, Melbourne.*—(i) *Pleuro-pneumonia of Cattle.*—The experiment on duration of immunity after vaccination by the use of standard culture vaccine, referred to in previous reports, was brought a stage nearer completion ; all groups have been vaccinated and are awaiting the final test. Inquiry into untoward reactions and deficient immunity after vaccination among cattle in northern Australia suggested that the strain used for vaccination, although not excessively virulent under laboratory conditions, was so under the local conditions, where cattle had been subjected to considerable hardship, and that furthermore it was antigenically deficient. It was replaced by a strain of low virulence which has given very atisfactory results at the laboratory and so far in the field. The experience appears to show that there is no constant association between virulence and immunizing capacity of the

micro-organism. The demand for vaccine continues to grow, and during the year 325,000 doses were issued. Work was continued on the problem of establishing a standard for immunizing capacity to be used in the production of culture vaccine.

(ii) *Entero-toxaemia of Sheep.*—Information yielded by the investigation of the trypsin-activation effect with the toxin of *Cl. welchii* type D suggests that, hitherto, strains for the production of vaccine have been selected upon a faulty principle and that considerable improvements in the immunizing capacity of vaccine should follow the application of the new principle. Vaccination experiments to test this were started but have not been completed.

(iii) *Caseous Lymphadenitis.*—The immuno-chemical studies outlined in the last report were continued, and a second nucleo-protein fraction was isolated. Both nucleo-proteins are present in a wide range of Corynebacteria. *C. ovis* treated with sodium lauryl sulphate proved to be highly antigenic for preparing agglutinating antisera but proved of no special value as a vaccine against infection.

(iv) *Bovine Haematuria.*—Further evidence was obtained in support of the hypothesis that top-dressing with gypsum delays the onset of haematuria. Pasture analysis indicated a higher molybdenum content in redwater areas than in " clean " areas, and a reduction in redwater areas top-dressed with gypsum. Experiments were started on cattle to determine the effect of continued small doses of molybdenum.

(v) *Myxomatosis.*—A field experiment under quarantine conditions was carried out on a rabbit population infested by the native stickfast flea, *Echidnophaga myrmecobii*. The population inhabited thirteen warrens distributed over an area of 90 acres and was estimated to number approximately 500. The disease was introduced into four warrens situated at about the centre of the enclosure. Subsequently the disease spread to all thirteen warrens and completely exterminated the inhabitants of most of them. Within 70 days the epizootic had spent itself and had killed all the rabbits with the exception of seventeen. These were caught and artificial inoculation with virus proved that all were susceptible. The disease had died out when the population had become so sparse that spread became difficult or impossible.

Work was continued on other epidemiological aspects of the disease.

(vi) *Mastitis in Dairy Cattle.*—Systematic clinical and bacteriological observations were continued upon the experimental herd which was maintained at the new farm at Werribee. The data will be examined to determine what change if any takes place in the bacterial status of each quarter of the udder with increasing age in the cow. Bacteriological and clinical studies were carried out on selected commercial herds in order to extend the study of mastitis and to compare results with those obtained in the experimental herd. The studies have not yet shown that the epidemiology of common infections of the udder differs in the several environments, although a difference in the type of bacterium predominating in the environments has been observed. During the year, the results of the study of the data collected during the first two lactation periods of cows in the experimental herd were published in Bulletin 134. Laboratory studies were made of several bacteriostatic substances which were thought to have possible value in the prophylaxis of mastitis.

(vii) *Toxaemic Jaundice.*—The co-operative investigation was continued. Outbreaks of the disease were few, and thus field studies were restricted. The field trial of a medicated lick was continued at the Experiment Farm, Barooga, but as the disease did not appear in the flock the value of the lick remains undetermined. Laboratory studies were continued on the attempts to depress excessive absorption and storage of copper by sheep. A joint paper on the etiology of the disease was published in the *Australian Veterinary Journal*, vol. 16, p. 233 (1940).

(viii) *Tuberculosis of Cattle.*—Continued studies on the complement fixation test for the diagnosis of tuberculosis of cattle have confirmed its value. The problem of deterioration of the antigen has been overcome. It appears that antigens from the bovine type of the bacillus are more satisfactory than those prepared from the human type.

(ix) *Peg-leg of Cattle.*—Statistical analysis of the results of the 1938–40 experiment has made it clear that the poor development, skeletal deformities, and losses associated with peg-leg are not due to simple phosphorus deficiency. In the new experiment, which is about to begin, the effect will be determined of a " lick " containing in addition to bone flour various " trace elements " that are now recognized as important to ruminant nutrition.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *Studies on Phenothiazine as an Anthelmintic.*—Dose rates and methods of administration have been investigated. Field trials in the control of the nodule worm (*Oesophagostomum columbianum*) showed that a single dose of 14 grammes gave satisfactory results in over 80 per cent. of sheep ten months' old and weighing about 50 lb. In older and adult sheep weighing about 80 lb., doses of from 15 to 20 grammes were similarly effective. Larger doses, viz., from 22 to 28 grammes, are needed to deal with the black scour worms (*Trichostrongylus* spp.), but even

these larger doses are less effective than against the oesophagostome. The drug was found to be very effective against *Nematodirus* spp. in doses of 0.6 grammes per kilo of bodyweight but was ineffective against the non-pathogenic *Strongyloides papillosus*. Phenothiazine in the form of a suspension of the two preparations on the market can be administered from a drenching funnel, but this suspension blocks the valves and jams the pistons of drenching syringes. Thicker suspensions can be used in drenching guns if they are frequently oiled and cleaned and provided with a modified valve. Phenothiazine administered in supplementary feeds and licks gave inconsistent results. A single large dose administered late in the winter gave encouraging results in the control of the nodule worm.

(*b*) *Studies on the Large Stomach Worm* (*Haemonchus contortus*).—It was found that a small proportion of a flock of sheep infested with this parasite will fail to respond to treatment with the usual copper sulphate, nicotine sulphate mixture but that it can be treated successfully with carbon tetrachloride. In an outbreak of haemonchosis a single treatment with phenothiazine is comparable in effect to two treatments with the usual anthelmintic drugs. Ten chemical substances were tested for their anthelmintic value against *Haemonchus* without one giving very promising results.

(*c*) *Studies on the Black Scour Worm* (*Trichostrongylus* spp.).—Experiments showed that large doses of larvae, up to 50,000, caused rapid loss of condition in young sheep. The course of the disease was very rapid, and death occurred in some cases in from eighteen to twenty days before the larvae had time to reach maturity. Other experiments showed that tetrachlorethylene, preceded by a small dose of copper sulphate solution is highly effective against trichostrongyles. The tetracholorethylene may be given most suitably in liquid paraffin, but staggering and partial loss of consciousness by some of the animals cannot be avoided.

(*d*) *Studies on the Pathogenicity of Nematodirus* spp.—Attempts to set up heavy infestations in pen-fed sheep have failed ; thus it has not been possible to study the pathogenicity of the parasite under laboratory conditions.

(*e*) *Recovery of Infective Nematode Larvae from Pastures.*—Satisfactory methods have been evolved for determining the relative number of larvae recoverable from grass blades and the soil beneath. It may be possible to measure the infectivity of pastures by these methods.

(*f*) *Parasitological Studies at Armidale.*—In addition to some of the trials already mentioned, a trial was commenced to determine the efficiency and economy of supplementary feeding, drenching at regular intervals, and drenching at periods governed by epidemiological considerations, in the control of diseases due to worm parasites. In another trial it was found that sheep rotated on natural pasture thrived better, grew more wool, and harboured fewer worm parasites than sheep grazed continuously at the same rate of stocking. Both groups received the same anthelmintic treatments. Epidemiological studies have shown that *H. contortus* infestation is acquired in spring, summer, and autumn months and is related to falls of rain of 30 points or more spread over several days. Nodule worm infestation is acquired in late spring, summer, and early autumn, but effects are not usually seen until the winter months. Trichostrongyle infestations are acquired in the late autumn, winter, and early spring, and effects may not appear until some months later. Large lungworm infestations are acquired in late autumn, winter, and early spring, and when the spring feed appears they are spontaneously thrown off by a process of " self-cure ".

(ii) *External Parasites.—Dipping Investigations.*—Work on the bionomics of the sheep ked was completed. Studies were continued on the resistance of the pupae, and field trials were carried out. The results of much of the work have been submitted for publication as a pamphlet.

(iii) *The Blow-fly Problem.*—(*a*) *The Mules Operation.*—Trials of the operation on lambs at marketing time were completed. It was found that more skill and experience are required when the operation is performed on lambs instead of older sheep. A proportion of lambs are inevitably under-treated and require re-treatment. Those requiring re-treatment in this trial constituted less than 10 per cent. of the whole. Ten weeks after the operation, observations showed that about 4 per cent. of the lambs operated upon were struck and most of these needed re-treatment. In a group of lambs that were not treated because they appeared to be plain-breeched, 20 per cent. were struck in the same period. Another trial was carried out on weaners, and three groups were set up, one of plain-breeched sheep which were left untreated, one of B and C class sheep which were operated upon, and the third of B and C class sheep which were left untreated. The aggregate strike incidence in these three groups was 11 per cent., 1 per cent. and 59 per cent., respectively. Studies on fly strike dressings were continued.

(*b*) *Parasites in the Skin of Sheep.*—Observations showed that a species of *Demodex* may be present in the skin without producing any obvious abnormality. A new mite parasite was found in the skin of sheep in at least two flocks. It was found to produce slight but chronic irritation in the skin. The fleece of affected sheep showed a thin, pencilly tip ; elasticity and tensile strength were impaired and the fibre was " perished " or " rotten ". The mite has been tentatively identified as a species of *Psorergates* belonging to the family *Cheyletidae*.

(iv) *Infectious Diseases of Sheep.*—(*a*) *Foot-rot.*—The investigations were concluded and the results recorded in Bulletin 140.

(*b*) *Infectious Ophthalmia* (*Pink Eye*).—Investigations were continued, but all attempts to isolate the *Rickettsia* which is constantly present in the affected conjunctiva failed. The presumptive evidence of its causative role is very strong. The *Rickettsia* occurs in two phases. In phase 1 it takes the form of small, uniformly-stained, intracellular bodies, and is seen in acute cases only. In phase 2 it occurs as larger, ring-shaped and horse-shoe shaped bodies which are mostly extracellular, and it is seen in the apparently normal eyes of carriers. Infection has been produced in the eyes of normal sheep with the tear secretion from animals that had shown no symptoms for more than 100 days. Contact of normal sheep with similar carriers in pens also resulted in the infection being spread. Recovered sheep are usually immune for from 200 to 300 days.

(*c*) *Balanitis* (*Pizzle-rot*).—Field observations and experiments have been continued and have led to a clearer understanding of the development and nature of the lesions in this disease. The early lesion is an ulceration surrounding the external orifice of the sheep. This lesion may either last but a few weeks and be followed by recovery or it may persist indefinitely. The process may extend within the prepuce. Progress may be slow or the lesions may heal spontaneously at almost any stage, but when the preputial orifice is narrowed relapses usually occur. All attempts at transmission have failed. Field observations and experiments strongly suggest that balanitis is related to diets that are rich in protein.

(v) *Biochemistry.*—(*a*) *Studies on the Mineral Metabolism of Sheep.*—Groups of sheep were maintained for many months on diets which were adequate except for a deficiency of lime in relation to phosphorus. It was found that deficiency of lime in the diet profoundly depressed the sheep's appetite. Growth and increase of body weight were thus seriously affected. Development of the teeth in young sheep was also retarded. The control group of sheep which received 1 per cent. of carbonate of lime added to the diet grew and fattened normally. These observations again demonstrate the value of lime added to the diet of sheep, particularly when supplementary grain feeds are used in times of drought. (*b*) and (*c*) Studies were continued on *carbon tetrachloride poisoning* of sheep and on *pregnancy toxaemia*. Suggestive evidence was obtained that pregnancy toxaemia may be related with hypocalcaemia.

(vi) *Chemical and Physical Studies on Wool.*—(*a*) *Fleece Chemistry.*—Studies were interrupted, but some routine work was performed during the year.

(*b*) *Physical Studies of Wool.*—Observations were made on the mechanism of felting, tensile strength, and elasticity of wool fibres.

(vii) *Wool Biology.*—(*a*) *Influence of the Plane of Nutrition on the Structure of the Merino Skin and Fleece.*—This work was continued in association with the Animal Nutrition Laboratory. Studies were carried out on strong-woolled and fine-woolled sheep. The plane of nutrition was found to affect the density of the fibre population. In general, greater skin growth was observed in sheep on the higher plane of nutrition, and this led to greater development of skin wrinkles. Among the strong-woolled sheep a high plane of nutrition increased slightly the variability in fibre size of the fleece, but in the fine-woolled sheep it reduced it slightly. The ratio of primary to secondary follicles was found to be 1 : 21 in the fine-woolled and 1 : 15 in the strong-woolled sheep.

(*b*) *Studies on the Histology of Foetal Skin, and Development of the Fleece in the Merino.*—This work was continued and provided information of great assistance in the interpretation of skin morphology in growing sheep.

(viii) *Statistical Work.*—The biometrical staff of the Division was centred, as in the past, in the McMaster Laboratory. During the year, this staff was transferred to the newly-created Section of Biometrics which is to control the biometrical work of the Council in the future, although the location of officers was not affected.

4. *The F. D. McMaster Field Station.*—(i) *General.*—(*a*) *Seasonal Conditions.*—From June, 1940, to 31st May, 1941, 2,108 points of rain fell on the Field Station. Because most of this fell late in the year, supplementary feeding for all sheep was necessary. Between 28th November, 1940, and 9th January, 1941, 1,072 points of rain fell; the dams were filled, and grass grew rapidly. The two new dams greatly increased the water conservation. Still a third new dam was completed towards the end of the financial year so that an acute water shortage such as that recently experienced should be unlikely in the future. There were no autumn or early winter rains of any magnitude. Approximately 100 acres were ploughed and sown, 50 of these with oats and 14 with red clover and Italian rye. About 50 tons of natural grass hay was cut and about 15 tons of Japanese millet was cured as stack ensilage.

(*b*) *Pastoral Conditions.*—The pasture improvement attempted on 140 acres by the association of subterranean clover and rye-grass has been a complete failure notwithstanding the initial success of the introduction. Rhodes grass has given promise of a possible means of increasing the carrying capacity. Twenty-two acres sown with this grass in the summer of 1940–41 have done so well that plantings will be extended in the season 1941–42.

(*c*) *Livestock.*—The shearing tally in October, 1940, was 742. The lamb shearing and crutching tally in March, 1941, was 930. The wool clip amounted to seventeen bales. At 30th June, 1941, there were upon the property 98 rams (entire and vasectomized), 640 two-tooth or older ewes, as well as 63 ram-and 108 ewe-weaners, a total of 909 sheep. In addition there were six draught horses, one draught foal, and one light horse.

(*d*) *Afforestation.*—Tree planting was impossible in the 1940 season, but land was prepared and other arrangements made to plant some 2,000 trees in July, 1941. These operations are under the guidance of the Commonwealth Forestry Bureau.

(ii) *Zebu Hybridization.*—A visit to the experimental herds was made in August, 1940. Data collected were presented in the Fourth Progress Report, prepared for restricted circulation in October, 1940. In addition, a report upon the project has appeared in the Council's Journal (Vol. 14, p. 161, 1941). Arrangements were made to secure two pure-bred Zebu heifers. These are to be brought to the Field Station, where they will be incorporated in the Sydney University dairy herd. With them and the Jersey cattle of the herd, co-operative work will be undertaken with the Officer-in-charge of the University farm. The observations are planned to investigate genetic characters of Zebus and Zebu x Jersey hybrids with regard to dairy production.

(iii) *Fertility of Sheep.*—The two studies designed to determine whether the discovered periodicity of oestrus is influenced by genetic factors, i.e., the breed or strain of the sheep, and is the same for similar sheep in dissimilar environments, have been continued. The results show that the breeding season is more restricted in some of the strains than in others and that it is not identical for all locations, although it is true that during the autumn and winter months the greatest number will be capable of being bred. Observations on the flock at the Field Station have added no support to the popular belief that the occurrence of abundant green feed after dry conditions will produce an early response in ewes and increase the proportion coming into oestrus. Actually in ewes going through this nutritional experience at the station, the onset of oestrus was delayed for approximately one month compared with the same period in previous years.

(iv) *Inheritance of Skin Wrinkles in Sheep.*—These studies were continued. Matings to increase the number of the first filial generation were repeated. The ewe progeny in the first filial generation that were old enough were mated with appropriate rams for the second filial generation.

(v) *Inheritance of Black Wool in Sheep.*—Further matings were made to investigate the heredity of black wool which may appear on large areas or on occasion cover the whole of the body. Results so far have suggested that the occurrence of black-coloured sheep closely approximates that expected for a mono-hybrid population, black being recessive. The number of sheep with known parentage has been increased in order to study the inheritance of pattern and thus elucidate the occurrence of small, discrete spots bearing black wool fibres in otherwise white fleeces. In all, 5,094 sheep were examined in the investigation of the incidence of spotting in sheep. It was determined that some strains of merinos have a higher incidence of discrete black spotting and that in all strains the incidence increases with age.

(vi) *Inheritance of Horns in Sheep.*—This investigation was continued. Matings in the special flock of polled sheep were made, and large numbers of sheep were examined for the development of a classification of frontal appendages and the determination of their incidence.

(vii) *An Inbred Flock of Australian Merinos.*—Observations were continued on the inbred flock which was primarily established to supply experimental animals in which the genetic variability was controlled. Fleece weights and characters in the parental generation were recorded and studied. The data collected have not been fully examined.

5. *The Animal Nutrition Laboratory, Adelaide.*—(i) *General.*—Work was continued during the year on investigations started some time ago. Following a request to the Council from the Quartermaster-General of the Army, tables containing the latest information on the composition of human foodstuffs were compiled for the use of the Army Catering Department. These were prepared in collaboration with the chemist of the Animal Products Research Foundation of the University of Adelaide. As cogent data suitable for the assessment of the nutritive value of mutton were not available, the staff of the laboratory voluntarily undertook the necessary determinations in their own time. The results were incorporated in tables and published in Pamphlet 107.

(ii) *Phosphorus Metabolism of the Sheep.*—All the experimental investigations on the metabolism of phosphorus by the sheep, whether conducted in the laboratory or in the field under conditions of station practice, have indicated that the widespread use of phosphatic supplements for grazing sheep is in no wise justifiable. The observations have been concluded.

(iii) *The Effect of the Administration of Fluorine to Sheep.*—The final observations on this experiment, which aimed at measuring the effect of fluorine on reproduction, were not conclusive. There was a poor lambing in both groups. The proportion reared by the control group was no higher, however, than that reared by the fluorine-fed ewes. Examination of the skeletons of animals from each group revealed that, although the intake of fluorine had no effect on the physical appearance of the bones, it did cause some mottling of the incisors and molars in the group intermittently receiving fluorine. Selective abrasion of the teeth was also apparent. This experiment has been concluded.

(iv) *Energy Metabolism.*—During the year, the main activity of the work on energy metabolism was devoted to the evaluation of the capacity of an additional series of feasible concentrates to provide the energy for maintenance of the sheep. This work was linked with the drought feeding programme. The value of acetic and propionic acids as sources of useful energy was investigated further, in order to bring the existing knowledge in line with the work on the digestion of cellulose discussion in the previous report.

(v) *Drought Feeding.*—Several lines of research have converged on the application of knowledge to the solution of two problems, viz., the determination of appropriate fodders for supplementary feeding, and the selection of the most economic complete rations for the total maintenance of flocks under drought conditions. The comparative capacity of a number of economically feasible concentrates, roughage, &c., to provide the energy necessary for maintenance of sheep has been determined, and the results have been prepared for distribution among pastoralists in the form of a nomogram which will facilitate the selection of the most economical rations for hand-feeding, as well as the determination of the amount of each that is necessary and the total cost.

(vi) *The Influence of the State of Nutrition on Wool Production.*—The experimental observations on the groups of young sheep referred to in the previous report have been continued. Data collected over the first year of the observations show clearly the extent to which quantity and quality of wool production depend on nutritional level. Furthermore, the obvious difference in conformation between the experimental animals on the high plane of nutrition and those on a low plane, even in twin animals, illustrates some of the difficulties encountered in selective breeding under conditions of variation in nutritive value of pastures. The strong-woolled group produced approximately twice as much wool even at low nutritional levels as the genetically fine-woolled group, thus illustrating that the wool-producing efficiency of various types of merino sheep differs markedly. The observations are being continued.

(vii) *Bovine Haematuria.*—The geochemical studies associated with bovine haematuria have been suspended.

(viii) *Plant Proteins.*—Experimental observations have led to the conclusion that leaf proteins of all flowering plants are of similar composition. During the year partial analysis of the proteins from the leaves of a selection of primitive types of plants were made. The composition of cryptogram tissue proteins appears not to differ markedly from that of the leaf proteins of the flowering plants. It seems extremely unlikely that the composition of whole leaf protein of any flowering plant could differ from that of any other flowering plant. In consequence, more complete analysis of the leaf proteins of typical fodder plants were started, and a large sample of protein was extracted from lucerne leaves which has proven to be of satisfactory degree of purity. Large-scale extractions of protein from the leaves of other plants will be made as material becomes available.

(ix) *Physiological Studies.*—(*a*) *The Process of Deglutition in Sheep.*—The study of the course taken by imbibed liquids through the complex forestomachs of the sheep was continued. Experiments were made to determine the effect of the temperature and the composition of the fluid imbibed on the course taken by the fluid. Observations on the path taken by suspensions of barium sulphate in water administered by gravity drenchings were extended until the experimental animals reached five years of age. Study of the mechanism underlying the influence excreted by solutions of cupric salts on the oesophageal groove reflex were extended. Neither osmotic effects nor the reaction of the solution was found to be responsible for the physiological action of the cupric salts.

(*b*) *The Absorption of Inorganic Materials from the Intestinal Tract.*—The observations on the influence of copper salts on the oesophageal reflex demonstrated a simple means by which liquids may be administered direct to the abomasum of some of the experimental animals.

Advantage was taken of this to study the absorption of copper from the alimentary canal by observing the copper concentration of the blood subsequent to the administration of copper solutions. In most instances a material increase in copper concentration was detected in the blood within 30 minutes. It is evident, therefore, that under the conditions of the experiment, copper was absorbed either from the abomasum or from the upper regions of the small intestine.

(x) *Coast Disease.*—(*a*) *Experiments at Robe, South-east of South Australia.*—Experimental work at this Field Station was continued, and another series of experimental trials was started. These aim to determine the ability of copper-dressed improved pasture to supply the sheep's copper requirements and to determine the efficacy of drenching sheep with cobalt at infrequent intervals when copper is supplied at frequent intervals. In order to study further the apparent difference in susceptibility of merinos and cross-bred sheep to grazing conditions that impose copper deficiency, an experiment was started in which matched groups of merinos and Border Leicester sheep receive copper supplements ranging from 0 to 100 milligrams of copper/day, superimposed on an adequate supply of cobalt. This will permit comparison of the performance of two breeds under conditions which extend from acute copper deficiency to considerable copper excess. The group of merino ewes offered salt licks containing copper and cobalt consumed in two years sufficient to provide approximately 100 milligrams of copper per day, which is an amount far in excess of their requirements. They have remained in perfect health and reared normal lambs. The copper content of the livers of these animals, collected at slaughter, ranged from 38 to 940 parts per million on a dry basis. Nineteen experimental ewes which were subjected to conditions of uncomplicated copper deficiency for two years at Robe dropped a total of sixteen lambs. Five were born dead, nine developed ataxia within four months, and two died of weakness without exhibiting symptoms of ataxia. Gross lesions of the brain, typical of acute copper deficiency, were observed in some of the still-born lambs.

(*b*) *Copper Deficiency in Sheep and Copper Metabolism.*—Observations on the wool from experimental copper-deficient animals at Robe have shown that the wool characteristically loses its normal crimp and becomes lustrous and straight or sometimes slightly wavy. By an examination on the wool floors, practically all clips in South Australia that exhibit " straight steely " fleeces have been recognized. The areas from which these wools came are widespread and extend from south-eastern South Australia to Eyre's Peninsula. In some places the occurrence of abnormal wool is seasonal ; in many it is associated with occasional outbreaks of ataxia ; and it is invariably accompanied by a history of the failure of lambs and weaners to grow normally. Copper deficiency was confirmed by blood analyses at several widely distributed sites, and in some places an associated incipient cobalt deficiency was indicated. In order to extend the observation, a series of six experimental sites were selected in regions typical of large tracts of affected country, and observations of the effect of copper, cobalt, and copper plus cobalt supplements were started on experimental flocks.

(*c*) *Cobalt Deficiency in Sheep.*—The studies of cobalt deficiency have been extended, more especially of incipient deficiency. Experimental work at Robe has demonstrated unequivocally that the sheep's requirements are little more than 0.1 milligrammes of cobalt per day. The amount available from pastures in some areas at times falls below this and the animals suffer untoward effects without the appearance of the well-defined signs of the acute deficiency. Estimation of cobalt in animal tissues is now possible as suitable methods have been perfected. The cobalt content of normal tissues is very low, and the concentration seems to be reduced only to about a half in some animals which die from the deficiency. The cobalt content of deficient pastures is reduced to very low limits. Arrangements have been made for Australian sources of cobalt to be utilized in the deficient areas. The supply of cobalt for supplementary feeding is now adequate and the price considerably lower than it was. Treatment which will allow the maintenance of vigorous health for sheep grazed on terrain where they would all die within a year from cobalt deficiency costs a small fraction of 1d. per head per year. Experimental work to determine the possibility of providing the cobalt by top-dressing the pastures with manures containing this element have indicated that this approach is not likely to be economically feasible, at least on the seriously affected calcareous sands.

(xi) *Agrostological Investigations.*—(*a*) *Sown Pastures and Cereals on Copper Deficient Soils at Robe, South-east of South Australia.*—Experimental investigations on the copper-deficient calcareous soils in the south-east of South Australia, have been continued. The prevalence of zinc deficiency in these soils was confirmed : lucerne, barrel medic, black medic, Wimmera rye-grass, *Phalaris canariensis*, cereals, and the naturally occurring Madrid Brome grass respond to an application of zinc sulphate. Lucerne has been established and has given high yields over a number of years following the original application of copper. This yield has been improved further by the inclusion of zinc in the copper fertilizer. Barrel medic and other pasture legumes failed each year on the experimental areas even when heavy dressings of copper were included in the fertilizer applied. Remarkable growth has been made by barrel medic in experimental

areas treated with zinc and copper sulphate. A dense sward resulted in the first year and seed production was abundant. In autumn of the following year, healthy vigorous seedlings had formed a complete ground cover. The growth of this species was negligible on adjacent areas which had received no zinc. Observations of the response to copper treatment have also been made on field peas, barley, rye, oats, and wheat. Remarkable increases have been obtained in the yield of Mulga oats. Experiments are being conducted to obtain further knowledge of the interactions between the combinations of the elements known to be limiting factors for plant growth on these soils. Much of the agrostological work on these areas is now being conducted as a collaborative effort between the Nutrition Laboratory and the Waite Institute.

(*b*) *At Wood's Well* (*90-Mile Desert, South Australia*).—An area of typical heath scrub has been made available for experimental work at Wood's Well, County of Cardwell. There is evidence to suggest that, for the greater part at least, the soils of the 90-Mile Desert are deficient in copper, phosphorus, and nitrogen. Investigations at Wood's Well have been undertaken in co-operation with the Waite Institute to determine the problems which may be encountered in the establishment of pastures in this locality, which is typical of large tracts of low-producing surrounding country.

V. SOILS INVESTIGATIONS.

1. *General.*—The work of the Division of Soils has continued with a wide programme of investigations. The Division is associated with, and works in close accord with, the Waite Agricultural Research Institute of the University of Adelaide, which provides head-quarters and laboratory facilities. A considerable part of the Division's activities lies in the field, and work has proceeded actively in three States, South Australia, Victoria, and New South Wales. In Queensland, the work on cotton soils by an officer seconded from the Division to the Department of Agriculture and Stock has been followed closely and an advisory connexion maintained. Owing to enlistment of some officers, certain field work has of necessity been curtailed, and further modifications in field and laboratory work may be necessary.

A pleasing feature throughout the year has been the ready co-operation of the Departments of Lands, Agriculture, and Forestry, and the irrigation services in the States concerned. All scientific effort in agriculture should be directed towards a better and fuller use of the land. The soil is of prime importance in this regard, and the soil survey provides the essential basic information for the proper development of land resources. It is felt that the study of land resources and potentialities should be one of the major concerns of the Soils Division, because this can only be completely done with the soil survey as a basis. It is hoped that the fullest possible co-operation of the States and the Division will follow in any developmental projects or surveys of potentialities. The various State authorities have given increasing support to the surveys, particularly in regard to the interest shown and the reliance placed on data supplied. The time is not far distant when no move in land development will be made without adequate soil studies in advance.

The field work has undergone certain changes from earlier operations. The trend has been towards less detailed surveys on a larger scale with more emphasis on present and potential use of the land. Previously the surveys were mainly directed towards mapping areas of intensive settlement, under irrigation, with small holdings of high productivity and value. This necessitated close work, especially as these soils were very variable for irrigation purposes and frequently in need for reclamation.

The survey of Waikerie completed the mapping of the chain of irrigated horticultural settlements in the Murray system in New South Wales, Victoria, and South Australia. The study of these mallee and river flat soils has given a clear picture of the value of various soil types for irrigation, enabling a reasonable estimate of new areas to be made.

Ecological work has steadily come into prominence, especially in making rapid reconnaissance surveys, such as on Kangaroo Island last year. Soil surveys vary in their nature according to the detail and information required for the proper use of the land. The scope of the survey is being widened by expanding observations to include erosion, land use, and comparative production of soil types with the object of setting out a plan for the best use to which the land could be put on present scientific knowledge. The association of agronomists, foresters, engineers, and skilled workers in animal husbandry, is essential for such study and is slowly being realized. The final step is rural economic studies beginning with the fundamental basis of the soil map.

2. *Soil Surveys.*—The summary of field work completed in 1940–41 is as follows :—*South Australia.*—(*a*) South-east District, 100 square miles, total now complete, 550 square miles (includes land use map) ; (*b*) County Victoria, 150 square miles (includes erosion and land use map) ; (*c*) Kangaroo Island, final reconnaissance survey, 1,000 square miles ; (*d*) Woolpoolool and Merreti Swamps, Murray River, 16,000 acres ; (*e*) Loveday Division Cobdogla Irrigation Area, 5,000 acres. *Victoria.*—Murray Valley Irrigation District, 35 square miles ; total now complete, 330 square miles. *New South Wales.*—Wakool Irrigation District, 600 square miles.

(i) *Wakool Irrigation District, New South Wales.*—The survey was begun in July, 1940, at the invitation of the Water Conservation and Irrigation Commission of New South Wales. The Wakool Irrigation District forms one of a group of irrigation areas in the south-west of New South Wales now being developed for pastoral purposes. The district is devoted to wool and fat lamb production entirely. An irrigation scheme is operating for the supply of 1 acre foot of water per 10 acres. It is essential that the best land most suitable for irrigation should be selected, because the water right applies to each holding at the present time, and all the land-holders are faced with the responsibility of development.

The area for survey is 800 square miles, occupying the territory enclosed between the Edwards and Wakool Rivers. It exhibits considerable variation, but the soil pattern is well defined. About 600 square miles are completed. An attempt is being made to collect information on the history of land use, stock-carrying capacities, and costs of development to irrigation, and to deduce a rating of the soils in terms of production capacity.

(ii) *County Victoria, South Australia.*—County Victoria cuts across the northern part of the brown earth zone in the South Australian wheat belt, about 120 miles north of Adelaide. It covers a broad strip 25 miles wide and 60 miles long, extending from the saline flats and the drifting soils of the coastal plain on Spencer Gulf, to the better brown soils of the highland, forming some of the finest wheat land in the State. The eastern portion of the County reaches the marginal mallee zone. The whole area forms an admirable unit for erosion study. A soil erosion, and land use survey is being made, with attention to the history of erosion, decreasing production rates, and the means necessary to stabilize the soils. The main aim is to provide a plan of proper land use for the use and guidance of the State and farmers in reclaiming, or at least preserving the remainder of the area in moderate production. Very interesting results are being obtained, and the farming community has responded strongly to the survey.

The survey is the first of its kind to be carried out in Australia, and, in undertaking it, the Division wished to demonstrate the necessity and the benefit from it, as well as providing some example for work in other States. About 150 square miles have been covered at the present time.

(iii) *Murray Valley Irrigation District—Cobram–Numurkah Area.*—The survey of the Irrigation Area was continued during the latter part of 1940, completing in all about 330 square miles, or roughly one-half of the total district concerned. Owing to lack of staff the survey was suspended at the end of 1940 until a favorable opportunity arises.

The Murray Valley Irrigation District in north-central Victoria has been partly developed to irrigation, but the survey has kept ahead of the channelling. The soils show considerable variation in type and in their relation to irrigation. The water right is three acre inches per acre, and since a minimum supply of one acre foot per acre is required for average crop growth, in summer, it is necessary for each land holder to select carefully the best quarter of his farm for irrigation purposes. The Victorian Department of Agriculture and State Rivers and Water Supply Commission, who have collaborated in the work, are directly enabled to use the survey material for advisory work among farmers, and in design of the channel system.

(iv) *South-east District of South Australia.*—The work began in 1937 in the lower south-east was temporarily halted in 1940 with the completion of a total of 550 square miles of territory comprising the five Hundreds of Riddoch, Grey, Nangwarry, Hindmarsh, and Young.

The land use has been mapped to show the state of development of the area, and suggestions can now be made as to direction of development. The interesting position of pine forest plantations competing with pasture, for the better land, has arisen, and it is now becoming possible to rate the soil types for productive capacity. A definite move in this direction is advisable. The expansion of the survey over adjacent territory is contemplated when staff become available.

(v) *Kangaroo Island, South Australia.*—In 1939, a reconnaissance survey was made of 1,000 square miles, forming part of Kangaroo Island, South Australia, to study the variation within soil groups and the general distribution of soils and associated vegetation. The survey grew out of the work on legume establishment (*see* (4) below) and the need to determine the zones for application of results. A second visit was paid to the Island in 1940 and the classification more definitely settled. The material has now been compiled for publication. The data afford a reasonable basis for interpretation of experimental results over those parts of the Island found more suitable for development. The solution of problems in fertility on these poor soils in a high rainfall zone opens up important possibilities for South Australia.

(vi) *Woolpoolool and Merreti Swamps, South Australia.*—At the request of the Lands Department, South Australia, a rapid survey was carried out on 16,000 acres of land adjacent to the Murray River about 12 to 17 miles north of Renmark. It included the basin of Woolpoolool and Merreti Swamps, for which an irrigation supply was readily available. The survey disclosed some disadvantages, particularly in the salinity of the territory surrounding the swamps; the eroded condition of adjacent land, which makes it unsuitable for complementary subdivision;

the unpromising nature of the soils in the swamp beds ; and the necessity for a drainage system. The only consideration likely to make the scheme suitable for settlement on economic grounds would have been a highly fertile bed to the swamps, a condition not realized. The report was unfavorable.

(vii) *Part of Loveday Division—Cobdogla Irrigation Area, South Australia.*—At the request of the Lands Department, a reconnaissance survey of 5,000 acres in the Cobdogla irrigation area was made in 1941. This area was prepared for irrigation 20 years ago when the remainder of the settlement was occupied. It was thought this additional section might provide suitable soils for extending the settlement, or, failing that, might be permanently abandoned as far as maintenance of irrigation structures was concerned.

The survey disclosed some variability in usefulness of the area, part of which could be safely abandoned and part, if economical to handle in conjunction with present water distribution, maintained as potential citrus land. The report set out the case for the final decision by the State authorities.

(viii) *Minor Surveys.*—Several minor surveys aggregating about 1,000 acres were carried through, in particular " Murray View " near Waikerie, South Australia, and Wood Wood near Piangil, Victoria, in both cases at the request of the respective Departments of Agriculture. A survey of the new research farm site at Canberra was made for the Division of Plant Industry.

(ix) *Cotton Soils in Queensland.*—For the past twelve months, an officer of the Division has been seconded to the Queensland Department of Agriculture and Stock to conduct soil investigations in the cotton districts. A visit was paid to Queensland recently to discuss the progress of the work and a programme for the next twelve months. The work is entirely under the direction of the Department, the Division acting in an advisory capacity only.

(x) *Aerial Photography.*—The use of aerial photographs has become standard practice for field use in soil surveys wherever practicable. The accuracy gained and additional speed made possible by their use makes them worth while, apart from serving as a record of land use and for base plans. It is current practice to use the photographs in the field for direct mapping, when as many as four sets of information may be recorded with different coloured pencils.

About 600 square miles of County Victoria, South Australia, were photographed by a commercial company this year. The photographs have not only been of the greatest use to the field party but have a high propaganda value among farmers with an erosion problem on their land.

3. *Laboratory Investigations—Chemical and Physical.*—(i) *Improvements in Laboratory Technique.*—Owing to the importance of mineral deficiencies in Australian soils, methods for the determination of traces of the so-called minor elements are constantly under review. Both the spectrograph and polarigraph are in use, as well as the purely chemical method of analysis. With the spectrograph, where only minute quantities of soils, soil extracts, plant materials, and plant ashes are concerned, the technique of sampling and sub-sampling is important, and attention has been given to this problem. The concentration of solutions of soil extracts is receiving special notice, the final evaporation being carried out in the electrode itself. The equipment and technique for the excitation and interpretation of spectra of soils and ashes of biological material are being further developed.

Spectrographic analyses were made for other Divisions of the Council and for various State Departments of Agriculture of such material as soils, broth samples, fertilizers, clays, and a range of plant materials including fruit-tree leaves, lucerne, and grasses.

Experience has shown that the polarigraphic method gives reliable results for the determination of micro-quantities of zinc, and work has advanced chiefly towards shortening the procedure, without sacrifice of accuracy. Considerable simplifications have been effected along three different lines. These involved a study of various basal solutions that would be specific for zinc, a study of the partition of zinc between a chloroform solution of dithizone and aqueous ammonium citrate buffers of different pH values, and an investigation of various methods of ashing plant materials. As little as 3 microgrammes of zinc in a plant can now be readily determined with an accuracy of $\pm$ 2 per cent.

In view of the importance of phosphate fixation by certain soils encountered during soil surveys or in the course of field experiments, laboratory methods are being developed for estimating the phosphate-fixing power or alternatively the anion exchange capacity of soils.

The mechanical analysis of soils has been subject to further refinement, particularly with reference to the improvement of the technique of sieving and securing greater detail in the sand fraction. This greater subdivision is mainly justified when the data so obtained can be interpreted to give the distribution curve of the particle sizes in the non-colloid fraction of the soil. The method of mechanical analysis has also been shortened. The rapid hydrometer method now regularly used for mechanical analysis of soils in engineering practice and for routine work is also under review.

(ii) *General Soil Investigations.*—Modern methods for the examination of soil clays include the use of X-ray diffraction technique. As no apparatus is yet available to the Division, valuable assistance has been given by colleagues at the University of California and the University of Western Australia. Other methods of identifying the mineral constituents of the clays have been studied, particularly dehydrating procedures.

The colloids separated from a series of Australian soils developed on granitic and basaltic parent materials have been examined. It was found that the granitic materials had weathered to minerals of the kaolin type under a wide range of conditions, whereas in the basaltic soils the type of mineral reflected the soil moisture and drainage conditions during soil development. Kaolinitic types were observed under adequate moisture conditions with free drainage, whereas under drier conditions or those of impeded drainage montmorillonitic types were more characteristic.

In the course of field work in Tasmania in 1940, a group of soil types was observed in the Cressy District on which pasture establishment has been poor despite an apparently adequate supply of total phosphates. The soil in addition has shown a marked lack of response to phosphate fertilization. The soil is characterized by a clay mineral of the kaolin type and a relatively high content of iron minerals. Pot experiments have been carried out on these soils with encouraging results. Although the response to superphosphate alone has been negligible, the treatment of the soil with alkaline materials added in the form of lime, magnesia, limestone, or dolomite, sufficient to raise the pH to about neutrality, has given excellent results with subterranean clover. With superphosphate also added, responses have been even more marked. Excessive additions of alkaline materials caused a heavy decline because of the creation of an environment too alkaline for normal growth of subterranean clover.

(iii) *Mineral Deficiencies.*—Experiments begun last year have been continued with the soils of the prune orchards at McLaren Flat near Adelaide, where a disease resembling " little leaf " occurs. Pot experiments were carried out with the object of diagnosing the cause of disease by growing annual plants under different fertilizer treatments, those plants being selected which exhibit well-marked symptoms when certain elements are withheld. This method of using plant indicators yields more reliable information than chemical analyses of soils. It has been demonstrated that the light soil at McLaren Flat is deficient in boron and manganese. The next step is the repetition of the trial under field conditions to prove the deficiency. So far boron has been shown to be lacking, and further experiments are in progress. The field work has been done in colloboration with the Horticultural Branch of the South Australian Department of Agriculture.

During the course of the soil survey of Waikerie Settlement, South Australia, in 1940, observations were made on the occurrence of " little leaf " in trees and its association with soil and environmental factors. A report was prepared for the Department of Agriculture.

4. *Soil Microbiology.*—Investigations were continued on particular aspects of symbiotic nitrogen fixation. The study of strain variation with particular reference to strains of *Rhizobium meliloti* and the competition of effective and non-effective forms confirmed results previously obtained with *R. trifolii*. The host plant is the most important factor controlling effectiveness. If a compatible host plant is found all strains are effective. Strains effective for pea-nut, lima bean, and the Bombara ground-nut (*Voandzeia subterranea*) have been isolated, and successful inoculation of the last two plants secured. The technique of studying tropical legumes in pot experiments under southern glasshouse conditions in summer is proving difficult to perfect. The possible antagonism of different types of strains has been examined further. The effective strain is always dominant, even when introduced six weeks after the non-effective strain ; it readily enters the host plant and produces an immediate recovery from nitrogen deficiency. This aspect is often of considerable importance in South Australia where pastures are being established.

The drying of cultures has been adopted for storing strains, using a technique of drying under vacuum. It may prove possible to modify the technique for practical seed inoculation. Cultures have been dried upon various protective colloids and the viability of the organisms studied. A satisfactory degree of efficiency in seed inoculation for field sowing can be obtained when the powder is suspended in water immediately the vacuum-sealed tubes are broken. If the rapid loss of viability of the organisms on exposure to the air can be avoided, the technique may prove practicable for distribution of cultures.

The practical problem of establishing legumes on the poor lateritic soils of Kangaroo Island, South Australia, has been further studied with promising results. Copper deficiency has been an important factor in these soils, limiting seed production by legumes. A close contact with various settlers endeavouring to bring poor soils into production has been maintained continuously. There has been a persistent demand by farmers for cultures for inoculation of field legumes, and a record number of cultures was supplied for the 1940 season.

VI. IRRIGATION SETTLEMENT INVESTIGATIONS.

A. Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria.

1. *General.*—The Commonwealth Research Station, Merbein, is mainly concerned with problems of the dried fruit industry. At present time soil preservation and reclamation problems, and fruit processing, comprise the major projects, viticultural and irrigation problems on the horticultural lands being less pressing.

The normal seasonal development of the annual growth on a vine, including the development of the fruit buds, has been established by observations over a number of years. During the past three seasons special maturation studies have been carried out, and the results of the investigations given to settlers. The year 1938–39 was characterized by extreme summer heat, causing the grapes to ripen early ; the following year was cool, and ripening was very late ; and in 1940–41 monsoonal rains resulted in an early wastage in many cases. Extreme variability being a characteristic of the Australian climate, the grape producers desire a continuation of the maturation studies. The results of the investigations are expressed as curves showing the growth of the shoots and the berries, and the sugar rise and acidity fall of the grape juices. The curves are sufficiently regular to permit a fairly accurate estimate of the date of ripening ; and harvest operations and pre-harvest irrigation are now timed each year accordingly.

The results of the major investigations are applicable to all dried fruit areas in the Middle and Lower Murray River districts, though it is necessary to supplement the investigations in other centres on account of varying environments and conditions. The results of the major irrigation, viticultural, and fruit-processing investigations are now well established throughout the districts concerned, resulting in a marked similarity in the routine work of the producers.

The experience gained in the drying of fruit during trials carried out over a period of many years is proving most valuable during war time, when supplies of dipping materials such as potash and olive oil are limited.

2. *Co-operation.*—There is a close co-operation with other branches of the Council, particularly the Division of Soils, which has rendered continuous assistance in the planning of soil, irrigation and drainage investigations. and with the Division of Plant Industry, in the irrigated lands of the Riverina. A very pleasing basis of co-operation with State officers engaged on similar work has evolved, and joint investigations are being carried out in several centres with State officers dealing with irrigation and horticultural problems. It is a pleasure to acknowledge again the assistance rendered by primary producers' organizations in the various irrigation centres where facilities for field investigations have been made available to any extent desired.

3. *Drainage Investigations.*—Agricultural drainage is the chief method by which the productivity of the light textured soils of the dried fruit areas is preserved, and the drains are also essential for reclamation. The reclamation mains in the Mildura district, which constitute the outfalls for the internal drainage systems, are now complete ; and the investigations dealing with the optimum depth and spacing of drains for the major soil types are well forward. The publication of soil survey bulletins for the Mildura, Merbein, and Red Cliffs areas is proving a most useful factor in assisting growers to define the drainage plan for their particular holdings. A review has recently been made of the annual returns of the Mildura area, which has been in production for over 50 years. These returns show an increase of approximately 40 per cent. over the last twelve years, with minor extensions of the planted area. Although some of this increase is due to improved routine practices, it is considered that drainage and reclamation are the major factors contributing to the improvements. The general viewpoint is that the productivity of the drained irrigation lands should continue indefinitely.

Internal drainage in most of the settlements has reached the stage where a wide selection of sites and methods of drainage on private holdings is available, and it has been found possible to secure considerable variation in the depth and spacing of the drains. In some settlements, and for some soil types, it has been necessary to adopt the more arduous procedure of constructing experimental drains, or their equivalent, and providing a temporary outfall for the outflow of drainge waters. Measurements include the quantity of irrigation water applied, the run-off, and the rate of fall of the free water in the spaces between the drains. By means of close observation points (approximately 10 feet) the lateral influence of the drain may be determined with considerable accuracy. Attention has first been given to the settlements in which systematic arrangements have been made for the disposal of drainage waters ; and for these settlements, tables showing the optimum depth and spacing of drains for the main soil types have been prepared and are being utilized by the land-owners. A distinction has been made in regard to the intensity of drainage required, as drainage for reclamation warrants closer spacing than drainage for soil preservation. Plant surveys, indicating the rate of recovery of productivity, have been found very useful in all reclamation studies.

Drainage of horticultural lands is also proceeding in the Nyah and Woorinen districts (Victoria) following investigation of the drainage response of the principal soil types. In South Australia, the investigation of the drainage reactions in light-textured soils is almost complete, and a commencement has been made in studying the heavier soil types, including some of the heavy river flat types. On irrigated lands producing other crops, and on some of the heavier soils in the horticultural areas which show a limited response to agricultural drainage, the cost is considered excessive.

4. *Irrigation Investigations.*—The irrigation requirements of a number of major soils, and the methods by which these requirements can be secured, have been extensively investigated from time to time. It is relatively easy to define methods by which land can be economically and efficiently irrigated. Growers, however, show little inclination to improve their practices. Excessive applications are still common, though some advancement has been made by shortening the irrigation runs and by spacing furrows in relation to the nature of the percolation profiles. The quantitative value of irrigation water is not yet appreciated in Australia, and in most seasons the supply exceeds the demand. Economies in distribution that have been brought about are due to the realization that excesses on some soils result in soil wastage. A closer approach to the minimum efficient application for the irrigation environment is becoming more necessary in recent years, because with irrigation extensions the ratio of supply to demand is narrowing. The results of investigations concerning the frequency of irrigation, in reference to the soil and the crops grown, have received practical recognition, and in most community irrigation settlements, the frequency of irrigation is now satisfactory.

The extension of irrigation to new districts in the Riverina in New South Wales has opened up a wide field for investigation. These include the study of appropriate methods and frequency of irrigation on a number of soil types on which irrigation experience is limited. In addition there are establishment problems, since the soils of heavy texture " cake " excessively and prevent the emergence of the germinating shoots. In less extreme cases, retardation of emergence appears to be associated with weaker growth. Initial steps for investigation of these problems include a soil survey now in progress, and the establishment of irrigation plots on which the problems are being studied.

5. *Viticulture.*—Viticultural studies have been continued on the same basis as reported last year. Improvement in the condition of bunches has again been obtained from using the T piece trells, and commercial application of this method has now commenced.

Fertilizer Trials.—Fertilizer trials on sultana lands show little change ; yield increases are usually associated with applications of nitrogen, and other fertilizers give little measurable indication of their effect on yield and quality. The present nitrogen status of Murray soils appears to be such that applications of 2 to 4 cwt. of sulphate of ammonia, or the equivalent in other nitrogenous fertilizer, give increases in yield up to 10 per cent. Leguminous cover crops react in the same direction, though increases are usually lower. On the whole, there is confirmation of the practice of using nitrogenous fertilizer in addition to cover crops.

6. *Fruit Processing.*—The study of the chemical and physical reactions involved in the drying process has been continued, and further information has been obtained regarding the parts played in the drying process by the oil, potash, wetting agents, &c. This information is proving very useful now that imports are restricted. For instance, it has been found possible to successfully replace imported olive oil by suitably emulsified Australian cottonseed oil. Similarly, by using wetters such as potassium linoleate in the cold dip for sultanas, it has been found that appreciable savings in the amount of potash required may be effected. Whereas when cold dip was first introduced, 1 cwt. of potash was used in drying about 6 tons of dried sultanas, some 12 to 15 tons can now be dried with this quantity.

During the past season it has been demonstrated that by burning sultana and other prunings and suitably extracting the resulting ash it is possible to obtain a potash solution sufficiently pure for dipping purposes. The quantity of extract obtainable in this manner from a given area of sultanas is normally sufficient to cold dip some two-thirds of the crop, and more than sufficient to temperature dip the whole of the crop. The ash obtained by burning packing house waste consisting of stems, &c., has been shown to be much richer in potash than cane ash, and for this reason its use in dipping has been less troublesome, and the results obtained have been very satisfactory.

Experiments on the control of mould growth on the racks during drying have been continued, and partial control seems possible by the addition of 1 per cent. salicylanilide to the dip mixture. Further work will be carried out in the coming season. The importance of the paraffin oil, casein, water emulsion developed last year as a wash for dried fruit has become more apparent. This emulsion applies protective films of both casein and oil and should prove of great value in the treatment of seeded lexias, and rain damaged fruit where the skin has been broken, by helping to seal the cracks and to prevent massing and sticking after packing.

Recently an investigation into the possibility of utilizing waste or low grade fruit for the production of cream of tartar and alcohol has been commenced.

7. *Cultivation Trials.*—A cultivation trial has been commenced on the Station vineyard, on a systematic layout designed to measure the results of different methods of land tillage. Briefly, the trial includes all common methods of working the soil, from deep ploughing and subsoiling involving the cutting of roots, to shallow working which leaves the roots practically unimpaired. Disc implements which tend to consolidate the soil are included, and also deep rigid type cultivation which gives a loose texture.

8. *Financial Assistance.*—Financial assistance to the Station has been well maintained by various organizations. Annual grants are made by the Australian Dried Fruits Control Board, the Mildura Packers' Association, the Nyah-Woorinen Research Committee, the Curlwaa and Coomealla Horticultural Advisory Committee, and the Red Cliffs Research Committee. The State Rivers and Water Supply Commission, Victoria, supplies irrigation water to the Station, and various local officers assist in the investigations. Contributions for the year totalled approximately £2,500. The major portion is allocated for investigations of general interest to the dried fruits industry, with minor amounts for investigations of local problems in the contributing districts.

B. Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith, New South Wales.

1. *General.*—The Irrigation Research Station at Griffith was established in 1924. It has 90 acres of irrigable land, 30 acres of which are planted up, and it is provided with good laboratory facilities.

The New South Wales Water Conservation and Irrigation Commission co-operated in the establishment of the Station and maintains an active interest in it, contributing £1,500 per annum towards the working expenses and providing land and water. Very helpful contact is also maintained with the Griffith Producers' Co-operative Co. Ltd., which has provided cool storage facilities for citrus preservation investigations.

In the early days of the Irrigation Settlement, irrigation practices were generally poor as judged by present-day standards, and water-logging of the soil caused great damage. The early work of the Station was devoted largely to the study of soil moisture, and following on this early work the problem of waterlogging has been largely solved. These early problems of the irrigation area have now given way to another problem, which is the deterioration of the soil following on many years of cultivation. This soil deterioration is responsible for the loss of valuable orchards which should be at the height of their production. The problem is concerned with soil structure which is being studied in great detail. Investigations of irrigation methods still continue. In fact, irrigation is closely related to soil structure.

2. *Orchard Survey.*—This survey, the objects of which were given in last year's Report, was continued. Complete figures are available for distribution, health, and extent of flood damage of all the crops of the Murrumbidgee Irrigation Area. These figures are derived from counts of trees as shown by the aerial photographs and are consequently much more accurate and comprehensive than those obtained by the more usual forms of crop production census. They have been made available to the various bodies concerned, and are already being used by the Water Conservation and Irrigation Commission to indicate the course of important administrative work, and by the Rural Bank in its economic investigations and in its work of financing the settlers. This information is of great importance where the question of suitability of crops or soil are concerned, since it is obviously desirable to know what crops are most suitable for a given soil and locality.

Statistical treatment of the data is now allowing the influences of the various cultural practices in vogue on the area to be separated from the superimposed effect of the individual farmer's efficiency. The data have already indicated the outstanding influence of a watertable on some crops, and further information is being obtained on the effect on the size and health of each crop, of the use of manures, and of methods of irrigation and cultivation. The extent to which the various crops are susceptible to damage by flooding such as may occur during periodic excessively wet winters has already been assessed, and also the modifying influence of soil and slope on this damage. The survey is the most comprehensive of its kind carried out in Australia, and many novel features have been incorporated in it. Many of the original aims have already been realized.

3. *Irrigation Extension School.*—During the year a successful Irrigation Extension School was held. This was designed to bring the results of recent research on soils and irrigation before extension workers and to discuss the application of this information to farm practice on the Murrumbidgee Irrigation Area.

The school was attended by about 80 members, including research, extension, and administrative officers of the four bodies represented on the Irrigation Research Extension Committee, namely, the New South Wales Water Conservation and Irrigation Commission, the Rural Bank of New South Wales, the New South Wales Department of Agriculture, and the Irrigation Research Station, Griffith. Settlers were represented by members of the Murrumbidgee Irrigation Area Co-operative Executive Committee and the Advisory Committee of the Station. Others who attended included officers of the Victorian State Rivers and Water Supply Commission, the Victorian Department of Agriculture, the New South Wales Department of Education, the Council's Divisions of Soils and Plant Industry, and Commonwealth Research Station, Merbein.

The school comprised eight sessions made up of a lecture of an hour followed by about two hours' discussion and demonstrations. The lectures covered the following subjects :—The soils of the Murrumbidgee Irrigation Area, soil moisture, soil structure, irrigation methods, waterlogging and seepage, extension principles and methods, and the extension worker in a changing world. One afternoon was spent in field demonstrations, and the final session dealt with a review and discussion on the general subject matter of the school, led by Professor J. A. Prescott.

A feature of the school was the emphasis placed on the need to study the soil as it exists *in situ*, and not only as a material collected below a 2 mm. sieve. Soil structure was shown to be of great importance in research and farm practice on the Murrumbidgee Irrigation Area and formed a recurrent theme in discussions on soil water and air relationships, root development and plant nutrition, and irrigation, soil, and general farm management. The appointment of discussion leaders for each session proved successful in stimulating fruitful discussion along important lines. Recorders were appointed for each session, and the proceedings are now being prepared for publication.

4. *Soil Deterioration.*—The effect of continuous cultivation and the traffic of implements, horses, and men puddles the soil, causes the formation of a " plough sole ", and changes the soil structure from the mellow open structure of a virgin soil, with its high proportion of pore space and voids, to a compact poorly aerated soil. The result of this is that the root system of trees that developed while the soil was fairly open can no longer function properly, many of the roots die, and the tree declines in health and becomes quite unprofitable. This type of soil deterioration is now serious on the irrigation areas.

Citrus trees on the lucerne plots of the green manure experiment are still quite healthy, though seventeen years old. These plots do not receive any tillage, and the presence of the lucerne prevents puddling by traffic. Trees on other plots which receive the usual tillage, however, show the progressive decline in health so common to trees of that age. This and other evidence available indicates not only that the cause of the decline is soil deterioration, but also indicates preventive and curative methods. Investigations are proceeding to evolve systems of management whereby tillage can be entirely eliminated without objectionable or harmful results, such as the growth of objectionable weeds, or adversely effecting the nitrogen status of the soil. The possibilities of the use of a grazing technique or of a mowing technique are not being overlooked.

5. *Soil Structure.*—The structure of the soil is studied *in situ* in pits, and soil monoliths are removed for further study in the laboratory. By impregnating the soil with wax and other substances, not only can the pore space be determined, but detailed studies can be made from sections. The pore space and the class of voids present are also studied by determining the suction force and by methods of aggregate mechanical analysis which give quantitative measurements. In this way the effect of various cultural practices on the soil structure and pore space can be accurately followed.

6. *Field Experiments.*—The field experiments laid down about seventeen years ago have yielded information of great value, and have contributed largely to the present knowledge of the principles of irrigation practice. A good understanding of the nutrition of fruit trees under local conditions, the control of soil moisture, and the way the soil structure is changed under different methods of management has also been obtained.

Since these first experiments were laid down, however, new problems have arisen, and the experiments themselves have indicated fresh lines of research. Besides this, great advances in the technique of field experimentation have been made. Preparations have, therefore, been made to plant up a new experimental field of a factorial design to cover a wide range of cultural, irrigation, and fertilizer treatments. In this field it is intended to investigate systems of orchard husbandry that include clean tillage and systems entailing the entire absence of tillage. The relation of these systems to irrigation and fertilizers will also be studied. As it is essential to use trees that vary as little as possible, and as it takes three years to raise nursery citrus trees, preparations for the experiment have been proceeding for some years.

In order to obtain some of the information sought in this experiment more quickly, a trial has been begun on a grove of uniform and mature trees. The treatments of this trial include systems of husbandry which embrace tillage and systems in which tillage is excluded. This experiment will yield preliminary results fairly quickly.

7. *Project Farms.*—Experiments are being extended to settlers' groves to embrace a wide range of soil and managerial conditions. These experiments, called research projects, have three treatments (i) summer clean cultivation, (ii) lucerne, and (iii) a subterranean clover sod kept free of weeds by grazing with sheep. There is only one plot for each treatment, on each grove, replications being obtained by repeating the experiment on several project groves. On these projects a comprehensive record is kept of the soil structure, root systems of the trees, watertable, soil permeability, soil salt, and other factors to determine changes due to the three systems of husbandry being tested. The projects provide material and opportunities for fundamental investigations of soil structure, irrigation technique, and other investigations in progress.

8. *Irrigation Investigations.*—During the year further progress has been made in developing the irrigation technique appropriate for particular conditions, and layouts for the contour check system have been designed and constructed on several groves, including those on the project farms. Various designs of checks and doors have been investigated to improve the technique of applying the contour check system. It is necessary to have equipment that is not unduly expensive and which will enable the easy control of fairly large flows of water and at the same time reduce scouring to a minimum. The correct sizes of basins and flows to obtain uniform irrigations for the various soil types have been investigated.

9. *Pasture Investigations.*—Field trials have been established to determine the most economic irrigation programmes for both winter and summer pastures and to determine the relative merits of winter and summer pastures. In the case of summer pastures the effect of rates and frequency of irrigation is being investigated, and in the case of winter pastures comparisons of different times of the first (germination) irrigation is being studied.

This work is being carried out co-operatively with the Agrostology Section of the Division of Plant Industry. This Section is also co-operating in the study of no-tillage systems of orchard husbandry which involve the control of weeds by grazing. Most agrostological investigations aim at obtaining the greatest herbage growth economically possible, but in this study the reverse effect is being investigated, i.e., the reduction of herbage growth to a minimum by means of grazing management.

10. *Citrus Preservation.*—The wilting of oranges due to moisture loss in storage was investigated and particular attention given to such factors as (i) the effect of wax emulsions, detergents, and borax used in cleaning and processing, (ii) the time of picking, and (iii) the position of the orange in the case. Wax emulsions reduced wilting, and the position in the case and time of picking were also important factors. This work was part of the co-operative work being carried out by the Citrus Preservation Technical Committee.

11. *Botanical Studies.*—Growth studies, root studies, citrus stock investigations, and inarching experiments carried out at the Station are reported under the Horticultural Section of the Division of Plant Industry.

VII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The year under review has seen a further extension of the work of the Division in the field of defence. The main development followed on the appointment of the Chief of the Division in August to the position of Assistant Controller of Timber under the Controller of Material Supplies of the Department of Supply and Development. The work was carried on within the Division and using the staff of the Utilization Section. This proved satisfactory for a period, but as the work grew in extent, the need for a full time officer in the Department with experience of timber became urgent. Consequently, in May, 1941, Mr. S. L. Kessell, Conservator of Forests in Western Australia, was appointed as Controller of Timber. The Chief of Division as Assistant Controller of Timber and his staff continue to advise as previously.

The Division has been able to render valuable assistance to the Department of Supply and Development and to the industry, and the overwhelming majority of individuals or trade associations contacted have expressed their appreciation of its work. This work has involved the review of permits to import timber, the examination of hundreds of specifications for all kinds of defence and munition needs, the submission of advice on substitutes, where necessary recommendations in regard to modified manufacturing methods or procedures, and finally, the overcoming of the natural resistance of users, who are accustomed to a particular timber and in whose minds it is regarded as the only possible material It can be claimed that the work of the Division in regard to the control of timber has resulted in savings in imports, saving in quantity of timber used, and saving by use of lower quality timber.

The Division's experience has also been used in such matters as the supervision of the drying of all timber for rifle furniture, which calls for specially rigid conditions, and the design and supervision of erection of a plant for the conversion of such timber into the form of blanks.

Officers of the various Sections have also been called on to assist manufacturers in adapting their practice to new timbers, and in doing this, it frequently happens that the new timber is found to be at least as good as that previously imported and believed to be irreplaceable. Match splints, for example, have always been imported to Australia. Many timbers have been tried and unfavorably reported on, but work at the Division showed that several of these were quite satisfactory. Hoop and radiata pine were early found to be quite satisfactory, but it is now most likely that one of the common eucalypts available in large quantity will be permanently established for this use.

In aircraft research, the outstanding feature of the year's work has been the setting up of standards for Australian timbers for solid members and plywood for aircraft.

There is great activity in Australia in the field of extending kiln drying. Some 700 kilns are in operation, which would probably be ample for ordinary times, but wartime demand for seasoned timber has led to big extensions, most of which are planned by the Division.

Flax investigations have been enlarged and increased staff appointed as a result of a grant from the Flax Production Committee. Both chemical and engineering research in this field are now centred in the Division and results of value are already being applied. It has been decided to revive the very interesting and promising work on chemical retting, temporarily dropped because of pressure of other work. The Division's officers are now in a position to advise on the control of water retting as this is rapidly extended according to plan. Problems of scutching, tow treatment, drying of retted straw, and control of dew retting are also being studied.

Owing the the war, there has only been one publication issued during the year—Trade Circular No. 47, *Nomenclature of Australian Timbers* (Standards Association of Australia Technical Standard No. 0.2—1940).

2. *Wood Chemistry.*—(i) *General.*—During the past year the research work has been designed specifically to serve the needs of the Australian pulp and paper industry. The main subjects which have received attention are carbohydrates and lignin of eucalypt woods, methods of pulp evaluation and paper testing, and fibre studies. The last-mentioned investigation is part of the programme drawn up in consultation with the pulp and paper companies, but is being undertaken by the Section of Wood Structure. The Section of Wood Chemistry co-operates in this work by supplying samples of pulp beaten in the various beaters at its disposal, and in correlating the changes in fibre structure with the beating effect as measured by standard sheet properties. Apart from the main co-operative research programme, various minor wood chemistry studies have been undertaken. Fifteen progress reports, mainly on the variables in the operation of the Lampen mill and on wood carbohydrates, were issued during the year.

(ii) *Carbohydrates of Wood.*—The study of the carbohydrates of wood has involved the separation of the total carbohydrate fraction of the wood into various fractions having various degrees of stability and of resistance to alkaline solutions. The fractionation has been effected by successive extractions of the total carbohydrate fraction with cold sodium hydroxide solutions of increasing concentration. The final residue from these extractions is regarded as the resistant portion, and considerable attention will be given to this in the near future. The aims of this investigation are to investigate the chain length of the wood carbohydrates, especially in the resistant fraction, and the nature of association of the hexose and pentose units both in this and in the less resistant fractions. In connexion with this, much of the relevant literature has been surveyed and a summary of this survey has been prepared.

(iii) *Lignin.*—The study of eucalypt wood lignin was commenced during the latter half of the year. At the outset, a critical examination was made of known methods for isolating natural lignin from wood. The result of this examination and a comparison of the different methods of lignin preparation have led to the conclusion that the most suitable methods for producing lignin that approximates the natural state are Hibbert's methanolysis method, Braun's " native lignin " method, and Braun's method involving pre-methylation of the wood. Before the actual isolation and examination of eucalypt wood lignin may be undertaken, two important preliminary problems have had to be solved. The first of these is the preparation of the wood and removal of extraneous materials especially tannins. The literature survey revealed that the wood should be used in the green condition because drying results in changes through hydrolytic or enzyme action. The comminution of tannin-bearing green wood presented some difficulty, which has, however, been overcome by initial conversion to buzzer shavings. Even in the form of shavings, the wood has had to be dealt with promptly, because changes, presumably due to oxidation, rapidly occur even when the shavings are stored under cold distilled water. The extraction of the wood to remove tannins was also a problem because the solubility of " native lignin " in alcohol and boiling water prohibited the use of these reagents. This difficulty has also been

overcome. The second important problem was concerned with methylating agents. It has been necessary to devote a considerable amount of time to the preparation of intermediates for the production of diazomethane as required. At the present time these preliminary tasks are nearing completion, and work on the main problem, that is the isolation and examination of eucalypt lignin, will be shortly commenced.

(iv) *Pulp Evaluation.*—The work on pulp evaluation methods has been mostly concerned with variables in the operation of the Lampen mill. The influence on the beating effect of speed, temperature, total charge, pulp charge, and stock concentration has been studied in detail using standard eucalypt kraft and, to a lesser extent using a coniferous kraft. Investigation of paper-testing methods has been confined to tear testing and, in particular, to the examination and correlation of different types of tear testers such as the Thwing Elmendorf tester, the Marx Elmendorf instrument, and an Elmendorf instrument that has been designed and manufactured in Australia. Some preliminary studies in connexion with the use of the Clark Kollergang type of beater in evaluating the beating effect have been undertaken. These have been concerned with the disintegration of 80 grammes of pulp in one operation, so as to bring it to the condition obtaining in the British Unbeaten Test which is designed for treating only 24 grammes of pulp in one operation. Some difficulty has been experienced in designing a suitable vessel for this operation, and in fixing the appropriate amount of treatment.

The study of the correlation between certain wood properties and the lignin content of the pulp prepared by the soda process has produced results which may prove to be of practical importance. From a knowledge of the hot-water-soluble content of a wood or of its alkali consumption when heated with dilute alkali under standard conditions, it is possible to fix the percentage of alkali to be used in cooking so that a predetermined lignin content of the pulp will be obtained.

(v) *Other Investigations.*—Of the minor wood chemistry investigations, that which is concerned with the effects of alkaline treatment on the chemical composition of wood is the most important. More recent studies have been applied to jarrah, a wood which is rich in extraneous materials that interfere with the determination of lignin and other wood constituents. It is anticipated that this investigation will aid in the selection of the mildest form of alkaline pretreatment which will remove these extraneous materials with little or no attack on the principal wood constituents. Analyses have been made of untreated and treated battery separators.

3. *Wood Structure.*—(i) *Investigations of Structure in Relation to Properties.*—This Section has been actively engaged in the systematic examination of the wood structure of all the specimens used in the Section of Timber Mechanics in their investigation of various Australian timbers for use in aircraft construction. The work has necessitated the employment of additional junior staff. The investigations of hoop pine and bunya have been completed and comprehensive reports prepared and circulated. The work on the test specimens of alpine ash from Victoria has been finalized and two reports prepared. The examination of the test specimens of alpine ash from Tasmania and of mountain ash from Victoria has also been completed and the results analysed. Considerable work has been carried out on specimens from other species under investigation, but more remains to be done. The results obtained have proved of value in that the effect of such features as reaction wood, minute compression failures, brittle heart, and rate of growth on the properties of the various timbers, has been determined, thus allowing more intelligent selection of the best quality material for the purposes required.

(ii) *Investigation of Reaction Wood.*—As indicated above, the effect of compression wood on the properties of hoop and bunya pine has been thoroughly investigated. Further, some preliminary experiments to determine the effect of tension wood on the normal properties of timber have been completed. The timbers investigated, namely, bollywood and blackwood, are both possible aircraft timbers, so that the investigations of the tension wood in them was of considerable importance. In certain experiments in co-operation with the Section of Timber Physics, the influence of tension wood on the longitudinal shrinkage of blackwood has been determined. One important finding in the case of blackwood was that the area of tension wood observed was found to correspond closely with an area of brittle heart (as indicated by the broken fibre test), thus demonstrating the great effect the formation of tension wood must have. This work will be extended when the test specimens from 30 trees of blackwood are available.

(iii) *Anatomical Investigations.*—During the year there was an increasing number of specimens of eucalypts brought in for identification by various public bodies, private firms, and individuals. This indicated the need for the re-examination of the commercial timbers of the genus *Eucalyptus* and for the modernizing of methods of identification. Such work has been in progress for the past eighteen months and is now nearing completion. Reports on various natural groups of eucalypts, namely, the boxes, ironbarks, gums, stringybarks, and bloodwoods, have been prepared. In addition, the information on the structure and microscopic features

of each commercial eucalypt has been transferred to a special series of identification cards specially developed for use with these timbers. These cards in preliminary trials have demonstrated their value in that their use in any identification quickly eliminates all but the few " probables " which can then be compared in detail.

Work has also been carried out on numerous Australian and Pacific Island timbers of the Araucariaceae, since the need for more positive methods of identification is increasing rapidly. A microscopic method for the separation of hoop pine (*Araucaria cunninghamii*) from bunya pine (*A. bidwilli*) has been developed.

With the more extensive call on the services of the Division as a result of the war, there has been a tremendous increase in the number of identifications submitted to this Section. The total for 1940–41 reached 651, which is nearly twice the number for the previous year. The co-operative scheme between the Section and the State Forests Services of New South Wales, Victoria, Queensland, and Western Australia, and the Commonwealth Forestry Bureau, has been continued.

(iv) *Fibre Investigations.*—These investigations have been continued, and the effect of beating various pulps in both the Lampen mill and the Valley beater has been studied microscopically. The pulps employed were (*a*) imported pine kraft, (*b*) imported coniferous (probably spruce) sulphite, (*c*) eucalypt kraft, and (*d*) eucalypt soda. The results obtained have been embodied in a series of progress reports. A brief survey has been made of different types of pulp beaten in the Lampen mill to determine the period of beating at which internal changes in fibre structure become most apparent.

The fibre investigations were also extended to cover the examination of different wood fibres for the Ministry of Munitions in relation to their identity and the effect of beating after nitration. Numerous fibre identifications have been carried out during the period under review.

(v) *Miscellaneous.*—Minor investigations have included an examination of the structure of numerous specimens of improved wood aimed at determining the exact location of the resin which is used to impregnate the wood before pressing ; the examination of certain specimens of Queensland maple rifle furniture ; and the preparation of various reports for, and in co-operation with, the Utilization Section.

One officer has spent a considerable time in the field collecting material for the work on timber for aircraft. At present there are 6,261 specimens of various Australian and Pacific Island timbers in the standard wood collection. The Section has continued to carry out a greatly increased amount of photographic work for the Division and for the Information Section at Head Office.

4. *Timber Seasoning.*—Laboratory work during the year was devoted almost completely to that associated with the development of kiln drying schedules for aircraft timbers. Species that have received particular attention are alpine ash (from Tasmania and New South Wales), mountain ash (from Tasmania and Victoria), Queensland silver ash, northern silver ash, and blackwood, the work on 1 inch quartersawn stock being now practically completed.

The kiln drying of Queensland maple and scented satinwood rifle furniture stock at commercial plants in New South Wales and Victoria also required considerable attention during the year. It was found necessary to give close supervision to kiln drying procedure at the plants concerned to ensure uniformity in, and the maintenance of, the very exacting seasoning standard required for the timber incorporated in small arms.

The demand for kiln dried timber over the past few years has grown rapidly and, despite the activity of kiln seasoning plants and the development of kiln installations in the Commonwealth to a total of some 700 kilns, as far as can be judged this demand is still greater than the capacity of the trade to meet it. It is not surprising, therefore, that, since the outbreak of war, requests to the Section for assistance in the design and layout of kiln installations have been particularly active, specific enquiries being received from 50 contacts. This required the preparation of approximately 400 blue prints, and their despatch not only to points in all of the Australian States, but even as far afield as New Zealand and Borneo. To determine the position, a thorough survey of the kiln installations in Australia was made.

A number of minor miscellaneous experiments were undertaken during the year. Among these were several in which co-operation was given to a smoking pipe manufacturer (of considerable European experience) with the object of establishing the suitability of Australian woods for this purpose ; several which aimed at determining the most satisfactory method of seasoning Australian timbers for boot lasts ; and others which were carried out in an attempt to discover the cause of " kiln burn " during the kiln seasoning of one of our pines.

Interest in correspondence courses in seasoning and kiln operation remained high during the year, 29 new students being enrolled. The total number of enrolments has now reached 301. A series of lectures in timber seasoning and research was also given, the syllabus being made appreciably wider in scope than had been the practice in past years.

5. *Timber Physics.*—The work of determining the effect of high temperatures, such as might be used in kiln drying, on the strength properties of timber has been completed for eight different species of timbers and is well under way for a further five. All these timbers are of potential value for aircraft construction and from the information furnished the Seasoning Section is rapidly developing safe kiln drying schedules. Work on the strength of timber at very low temperatures (such as may be encountered at high altitudes) is progressing satisfactorily, but insufficient results are as yet available to give an indication of the outcome of this investigation. The collection of data regarding the physical properties of density and shrinkage has been continued especially in connexion with the timbers proposed for use in aircraft. For these timbers variations within the tree and from tree to tree are being studied and also the correlation of high density and high longitudinal shrinkage with the presence of reaction wood. The studies have been extended to the density and shrinkage of plywood.

An important consideration in the choice of materials for aircraft construction, particularly for propellers, is the internal damping capacity of the material. The damping capacity is the ability of a solid to convert mechanical energy of vibration into internal energy and thus cause the vibrations to die out. The damping capacity of some fifteen species of timber and of various types of improved wood is being investigated. Already some very interesting results have been obtained. Also in co-operation with the Sections of Veneer and Gluing and Timber Mechanics, a study is being made of the properties and methods of manufacture of improved wood.

The demand for electrical moisture meters for use in the timber industry has been greatly stimulated as a result of increased activity in timber production in Australia, coupled with an increase in kiln drying. Owing to the difficulty of obtaining certain parts for the "Blinker" type of meter, a new type has been developed by a commercial firm in co-operation with the Division; this has proved very satisfactory and is entirely of Australian origin.

A new investigation commenced recently is aimed at determining the suitability of various Australian timbers for battery separators. Some millions of these, manufactured in the past mainly from Port Orford cedar from United States of America are used annually in Australia. A number of battery manufacturers are co-operating in the tests by machining separators from different timbers and by supplying batteries built up with these separators. Accelerated battery life tests and other tests on the separators themselves are being made at the Division.

General service has been given to other Sections in the Division, as well as to external contacts on matters pertaining to physical tests. In particular, mention might be made of the designing of conditioning rooms for the treatment of rifle furniture.

6. *Timber Mechanics.*—Work on the routine testing of Australian timbers to provide data to permit their use in aircraft has progressed satisfactorily during the year, over 40,000 tests, exclusive of moisture content tests, having been made.

(i) *Tests on Timber for use in Spars, Ribs, Longerons, &c.*—Tests on hoop and bunya pine have been completed, and those on blackwood, King William pine, alpine ash, and mountain ash are almost completed. Material from the following timbers has been received and is drying preparatory to testing:—Celery-top pine, white birch, sassafras, Queensland silver ash, northern silver ash, and silver quandong.

The analysis of the tests on hoop pine show that although about 20 per cent. heavier than spruce, weight for weight, it has equal or superior mechanical properties to that species, except in shock resistance—a property in which hoop pine is deficient. About 25 per cent. of visually selected hoop pine has an Izod figure greater than 5 ft. lb. An Australian standard specification for aircraft quality hoop pine has been issued by the Standards Association of Australia. Bunya pine is about 10 per cent. inferior to hoop pine in density and in all mechanical properties.

The tests on alpine and mountain ash show that for their weight these timbers have exceptionally good mechanical properties including impact strength. The Department of Civil Aviation has re-designed the stainless steel wing spars of a certain type of service aircraft using mountain and alpine ash and has found that with these timbers a more efficient wing spar can be designed than with spruce. Mountain and alpine ash appear to be the Australian timbers most likely to be used in aircraft for highly stressed parts and standard specifications for aircraft quality timber have been published.

King William pine has distinct possibilities for the many parts of an aeroplane which require a low density timber. The tests show it to have a density of about 85 per cent. of that of spruce, with correspondingly lower strength properties. The tests on blackwood have not been analysed, but it appears that the difficulty of obtaining straight-grained timber free from reaction wood is a definite disadvantage.

(ii) *Tests on Aircraft Plywood.*—Tests on plywood made from leatherwood have shown this timber to have very distinct possibilities as a substitute for birch plywood. It is markedly superior to scented satinwood (coachwood) in all mechanical properties but is not quite equal to

birch. Its only defect is a tendency to contain large numbers of pin-knots. Tests have shown that these do not appreciably affect the properties. In co-operation with the Aircraft Production Commission, a full scale commercial test is being made on leatherwood.

Tests on other species have been disappointing. Northern and Queensland silver ash have not come up to expectations and myrtle beech appears to be a borderline timber. If a lower strength standard than birch were permitted, however, a number of species would be suitable.

(iii) *Tests on Improved Wood for Airscrews.*—Tests have been made on numbers of experimental "improved" wood planks prepared by the Timber Physics Section, and very satisfactory results have been obtained, the properties of the improved wood being practically equal to that made overseas. Gluing difficulties have been overcome. Other work included the completion of the tests on split-ring connectors and the preparation of working loads.

The first edition of 6,000 copies of the Handbook of Structural Timber Design has been exhausted, and arrangements have been made for the printing of a second edition. The necessary alterations and additions were prepared.

7. *Wood Preservation.*—The normal work of the Section has been curtailed to a large extent during the year owing to the necessity for concentrating on investigations related to defence problems. For example, the research programme on fungi and decay problems has been abandoned, and the officer engaged on that work is assisting on improved wood investigations. The periodic inspections of the various test plots are continuing. Two major investigations with direct bearing on the preservation of future timber supplies have also been initiated. The creosote investigations have been continued, since this work is not a charge against the Council's funds.

(i) *Service Tests on the Less Durable Eucalypts.*—Test sections of sleepers, including a number of the less durable species of Victorian eucalypts, dipped or sprayed with creosote have been installed in the main Melbourne–Sydney track at Heathcote Junction and Glenrowan.

(ii) *Tests of Messmate (E. obliqua) Poles in Victoria.*—Detailed inspections were made of the test plots at Belgrave and Benalla as a result of which it was found necessary to carry out extensive re-treatments. At both plots open tank and pressure treatments with coal tar creosote were outstanding. The superficial treatments, e.g., brushing with creosote over sapwood, charring, arsenic collars, arsenic and sodium fluoride collars, are all breaking down. It was found that decay was thriving in the interior of poles treated in this manner at Belgrave, while decay and termites were responsible for the damage at Benalla. Oxyacetylene charring plus spraying with creosote was the best of such treatments.

(iii) *Tests of Various Pole Species and Treatments at Wyong and Clarencetown, New South Wales.*—An inspection was carried out in July, 1940. After exposures for 4 to 5 years the only treatments that are failing are those with zinc chloride and arsenic and with chemical bandages. No termite attack has been observed in any of the treated poles.

(iv) *Treatment of Green Timber (Diffusion Processes).*—(*a*) *Boric Acid Treatments.*—Schedules have been developed to treat sawn timber up to 2 inches thick of red tulip oak, white birch, and yellow carabeen to render the timber immune to Lyctus attack. Semi-commercial scale experiments are under way at the present time to obtain data on the design of suitable treating vats and treatment costs.

(*b*) *Green, Round Mining Timber.*—A simple method of treating green timber of low natural durability for use in a fairly dry mine was developed. The mine is in a very inaccessible position, and it was required to use timber growing in the vicinity, thus obviating the trouble and expense of obtaining timber of high natural durability.

(v) *Australian Creosote Oils.*—(*a*) The toxicities of different grades of Australian creosote and of different fractions from a typical Australian creosote and one American and one European creosote to three different wood-destroying fungi have been determined. The most toxic fraction of Australian vertical retort oils is that distilling between 225° and 275° C.

(*b*) The changes which take place in Australian vertical retort creosote oils when in use as wood preservatives are being studied. Matched samples in air and in water are examined at regular intervals and the changes noted. Water-leached creosote oils have been analysed and their distillation curves and toxicities determined. These tests have shown the chief effect of leaching to be loss of tar acids, loss of the more volatile portion of the oil, and a large drop in toxicity.

(*c*) The brown deposit on pressure-creosoted poles has been examined and compared with the residue from the water extraction of various creosotes. It has been shown to comprise a material soluble in the tar acids in the creosote. Prolonged heating of the creosote increases the amount of the residue.

(vi) *Treatment of Timber for Poles for Piling.*—(*a*) A number of ironbark poles have been treated by empty cell and full cell processes to obtain data on absorptions and penetrations. These treated poles are being kept under observation to observe the incidence of the " brown bloom " that occurs after a short while in service.

(*b*) A service test of ten open-tank-creosoted messmate piles together with controls has been arranged. The Victorian Forests Commission is supplying the piles, the Victorian Railways the freight on the piles, and the Harbour Trust Commissioners £200 towards the cost of the work.

(*c*) Drawings and details of a pressure-creosoting plant were prepared for the State Electricity Commission, which is considering the installation of either a pressure plant or an open tank plant for the treatment of poles.

(vii) *Tests of the Fire-retardant Qualities of Several Fire-retardant Paints.*—A number of tests were carried out on fireproof paints submitted by the Department of Defence Co-ordination. It was shown that several local paints were as effective as an imported paint of established reputation.

(viii) *Miscellaneous.*—A report was prepared and recommendations made for improving the present procedure for the waterproofing of paper sandbags. A simple hot and cold bath treatment to give better absorptions and penetrations than the usual cold dip was developed for the treatment of scented satinwood (coachwood) rifle furniture with linseed oil. Considerable time was devoted to queries regarding damage due to borers and termites and a number of inspections were made.

8. *Veneering and Gluing Section.*—(i) *Veneering, Drying, and Tego-bonding of Australian Timbers.*—The experimental peeling of Australian timbers for the manufacture of aircraft plywood has been the main line of work undertaken throughout the year. The aim of the investigation is to obtain an Australian substitute for birch (Betula) plywood. Altogether 197 lengths of twelve different species have been peeled into .01 in., .03 in., 1/48 in., and $\frac{1}{16}$ in. veneer. The veneer has been dried under low temperature schedules and bonded with Tego film. Subsequent testing was carried out by the Timber Mechanics Section. Leatherwood (*Eucryphia billardieri*) proved to be the most promising substitute, and as a result of the experimental work a commercial test of logs from 30 trees is under way at the present time. Logs of a number of other species from New South Wales are being collected, and the testing will be continued as the logs come to hand.

Two other lines of work include a preliminary investigation of the peeling characteristics of karri (*Eucalyptus diversicolor*) and mountain ash (*Eucalyptus regnans*). The former species is being studied from the viewpoint of its possibilities as the basis for the establishment of the plywood industry in Western Australia. The latter species may be suitable for match splints and its peeling characteristics are being investigated with this end in view. It has been shown that it can be peeled into a good tight veneer 1/12 in. thickness which should be suitable for splints.

(ii) *Specifications for Aircraft Plywood.*—Assistance was given in the preparation of Emergency Standard No. (E)D 804—1940—Australian Standard Specification for Aircraft Material—Plywood. This specification is the Australian equivalent of BSS.5.V.3.

(iii) *Testing and Examination of Glues.*—Many tests have been carried out with an Australian proprietary heat-reactive glue. This is a thermo-setting, casein-base adhesive which gives very water-resistant joints. It has been proved satisfactory for the bonding of plywood.

Tests have also been carried out on two locally made liquid resins to determine their characteristics and suitability for use in the manufacture of plywood, and it has been shown that a satisfactory plywood can be manufactured.

A number of caseins were analysed and reports prepared on their suitability for glue-making. Assistance was given in the preparation of specifications for joiners glue and casein for glue-making. These specifications have since been issued by the Standards Association of Australia.

(iv) *Utilization and Testing of Plywood.*—Numerous tests have been carried out throughout the year on plywood, veneered doors, and other laminated products. As a result of this work, red lauan (*Shorea* spp.) has been accepted as an alternative timber to Queensland maple for special purposes. Pepperwood (*Cinnamomum Laubatii*) has also been shown to provide a useful plywood.

Another investigation has disproved the oft-quoted theory that the temperatures used in Tego bonding weaken the timber. It was shown that there is no significant difference between the strength of $\frac{1}{2}$-in. Queensland maple 3-ply bonded with Tego film under a temperature of 300° F., the above-mentioned heat reactive glue No. 2 (250° F.), and a cold setting casein glue

9. *Utilization.*—The work of the Utilization Section has changed materially in the past year as its staff, closely associated with the events leading to timber control in the Department of Supply and Development, has devoted itself to the duties of the control since the Chief of the Division was appointed Assistant Controller of Timber in August, 1940. Besides dealing with the technical problems relating to specifications for the wide range of products required by the Departments of Air, Army, Navy, Supply and Development, and Munitions, the Section has taken a leading part in establishing the relations and organizing the application of timber control. In the solution of technical problems the Section has drawn upon the information built up from experimental investigations conducted within the Division since its foundation and from inquiries conducted for many years in the practical field of timber utilization. In the solution of supply problems, the utilization index of producers, holders of stock, products, and manufacturers has been invaluable. The programme of research by projects has necessarily been modified to enable efforts to be concentrated on inquiries of great urgency arising out of, or directly related to, the war effort. The progress of the year's work in timber utilization is inseparable from the timber control activities and the main activities have been as follows :—

(i) *Survey and Advisory Work.*—The Section has collated information on production and consumption submitted from each State and summarized the timber supply position in Australia. The Officer-in-Charge has acted as Secretary to the Central and Victorian Timber Advisory Panels set up to advise the Controller of Timber and has acted at Army Head-quarters as a liaison officer between the Division and the respective Service Departments ; he has participated in conferences on rifle furniture, bridging stores, wood containers for munitions, foodstuffs and clothing, &c. Information has been supplied to the Department of Trade and Customs, the Advisory Panel on Defence Works, Aircraft Production Commission, Contracts Boards, Directorate of Ordnance Production, and the Department of the Interior. Attempts have been made to obtain forecasts of demands for timber and to contact all ordering authorities. A system of regular notification of all orders for timber defence purposes is now operating, and from this notice of impending requirements is given to the timber trade.

Relating to defence, advice was given on timbers suitable for purposes including the manufacture of ammunition boxes, bridges, charcoal for explosives, crutches, gymnasium equipment, ladders, pattern making, poles, and tent poles and pegs.

Regarding civil inquiries, advice tendered related, for example, to archers' bows and arrows, barrels, battery separators, butter boxes, cotton reels, fishing rods, ice-cream spoons, matches, mining timbers, pencils, resin and turpentine production, and smokers' pipes.

(ii) *Grading Australian Timbers and Preparation of Standards.*—The secretarial work of the Timber Sectional Committee of the Standards Association of Australia was continued. The editorial work to incorporate approved revisions in the *Nomenclature of Australian Timbers* was completed and this was published as Australian Standard No. 0.2 by the Standards Association and as Trade Circular No. 47 by the Division. This publication is regarded as an important contribution to the progress of the timber industry, because it aims to standardize the names of Australian timbers and so remove the confusion attributable to the multiplicity of names previously given to certain timbers. A drive for the adoption of standard names has been initiated.

The draft Australian grading rules for Part 2 of Australian Standard No. 0.4 and 0.5—Milled Lining and Milled Weatherboards respectively, of the draft Standard for Structural Timbers, and Part 1 of the standard for Unseasoned Dressing Quality Sawn Timber prepared from specifications circulated to various State sub-committees, were edited. Assistance was given in the preparation of specifications for aircraft timbers, rifle furniture, boat veneers, and oars.

(iii) *Substitution of Australian for Imported Timbers.*—Because of reduction of imports by Customs regulations, Australia has been forced to rely to an increasing degree during the year on native timbers. This has stimulated a demand for information on the availability and properties of native timbers and, in order to expedite the handling of inquiries, the filing of information on species was improved, and a punched card sorting system applied to summarize the data on each timber. Recommendations were made as to the suitable substitutes for ash, aspen, Balsa wood, Baltic timbers, boxwood, Douglas fir, hemlock, hickory, maple, yellow pine, redwood, sugar pine, teak, yew, and sycamore. Attempts were made to locate Australian timbers for many common and specialty uses. The case-making and building trades have made many requests for Australian substitutes for Douglas fir and hemlock. To assist in the substitution, particularly for defence works, a mimeographed list of " Timbers for Various Purposes " setting out timbers in various States suitable for heavy structures, posts, poles, and sleepers, building framework, concrete form-work, flooring, weatherboards, lining, joinery, furniture, cases and plywoods was distributed through the Department of Defence Co-ordination to all architects and officers in Government Departments concerned with preparing specifications.

(iv) *Building.*—Close contact was established with the Department of Defence Co-ordination and the liaison section of the Works and Services Branch of the Department of the Interior in connexion with defence works. In the early months of the war, when all considerations were subordinated to speed of erection, examples were in evidence of wasteful use of timber through the specification of highest qualities, or of unnecessarily large or uncommon sizes in species obtainable only at great distances from the site of the works. After liaison was established with the Works Branches specifications were reviewed and many suggestions made to effect economies, overcome supply problems, and to expedite construction.

To promote further economy in timber utilization, a statement covering species of timber and sizes for all important construction members for permanent and temporary buildings was prepared. This was issued as a mimeograph, "Recommended Sizes for Building Frame Construction," and distributed through the Department of Defence Co-ordination.

The Section assisted in revising the *Handbook of Structural Timber Design* and preparing new tables and chapters for the second edition.

(v) *Cases.*—The survey of requirements for munitions, foodstuffs, and clothing was undertaken. A special committee on munitions boxes was set up to review the design of cases for defence uses, and an officer was assigned to the work of re-designing to effect economies in material and in costs. Two re-designs leading to considerable savings have been approved. The number of acceptable timbers for munitions boxes has been greatly increased.

(vi) *Supply Problems.*—Inquiries were conducted for the Department of Supply and Development as to the availability of materials required for the execution of defence contracts, and assistance was given to contractors in difficulties. Liaison has been established with the Shipping Control Board in order to expedite interstate shipping of timber for defence needs. Efforts were directed towards ensuring that supplies of certain timbers were directed into the most essential uses. Applications for permission to import timber have been scrutinized and recommendations made in respect to each individual case. An officer spent some months in North Queensland conducting negotiations for the supply of timbers for rifle furniture and investigating supplies of North Queensland timbers available for other defence requirements. Officers also collected in North Queensland and Tasmania representative logs of species being tested for aircraft construction purposes by other Sections.

10. *Flax.*—With the rapid expansion of the flax industry in Australia, many of the research projects referred to in the last annual report have been greatly expanded. Staff increases have been made possible through a grant from the Flax Production Committee of the Department of Supply and Development and a close liaison has been established between the other flax work of the Council and the Flax Production Committee.

Tank retting has been studied in detail both at the Colac rettery, and also in the recently designed small scale retting plant in Melbourne. At Colac such matters as the uniformity of the ret, the comparison of different types of ret, the application of pH measurements and electrical conductivity to the determination of end-point, the effect of the presence of short straw and weeds on the fibre yield, and the influence of deseeding by decapitation on the yield of fibre have been investigated. Recently the Courtrai type of ret, embodying a daily dilution, has been tried at Colac with very promising results. An increasing demand is being made on the retting facilities of the laboratory for treating flax grown in different States and in various field experiments. Close co-operation has been extended in all cases as the value of this work is realized.

Closely connected with tank retting is the important subject of artificial drying, and large scale dryers are in course of erection at two centres using a design based on the results of small scale work carried out by officers of this Division. The effect of artificial drying on the spinning quality of the fibre has been investigated and the conclusion reached that, provided the drying temperature is not excessive, adverse effects do not result from this treatment. A conditioning unit has been designed and is now used for bringing straw to the correct moisture content for scutching. Similar units will probably be installed at a number of mills.

The subject of chemical retting, which for a time was held in abeyance on account of the urgency of tank retting tests, has now, with the recent increase in staff and laboratory facilities, been resumed, and a detailed scheme for further investigation of the types of chemical ret already found partially successful has been prepared.

At the mills, extensive studies have been made of factors affecting the performance of scutching machines, including the effect of moisture content, rate of feed of straw, speed of beaters and various mechanical adjustments. Experiments on the decortication of green straw were carried out in the latter half of 1940, and breaking equipment was developed for use in conjunction with the standard scutcher. However, a subsequent change in requirements led to the abandonment of almost all decortication. A recent proposal is to use decorticating rollers for the purpose of tow production from very short straw ; preliminary tests have given promising results.

Other matters of interest dealt with in the laboratory include improvements in the technique of tensile testing, the design of an impact machine for fibre based on the Izod principle, water analyses in relation to retting quality, chemical analyses of flax fibre with special reference to their connexion with fibre quality as determined by a professional grader, the design of an electrical moisture meter for testing flax fibre, and further research on the purification and disposal of effluents.

VIII. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—The shortage of refrigerated cargo space for the export of foodstuffs from Australia has resulted in widespread changes in the food industry, and, consequently, the work of the Division of Food Preservation and Transport has recently been considerably altered so that adequate help may be given on pressing problems such as the disposal of surplus fruit and the conversion of certain foodstuffs into less perishable forms suitable for shipment as non-refrigerated cargo. Certain investigations, such as those on fish preservation and some aspects of fruit storage, have been curtailed, while more attention is being given to such matters as the preparation and storage of dehydrated eggs, meat, and vegetables, the preparation of fruit products, substitutes for tinplate containers, and general problems of canning.

The Division's help is constantly being sought in connexion with the exacting requirements for the supply of foodstuffs to the fighting services overseas. A close liaison has, therefore, been established with the authorities responsible for placing the contracts. The advisory work has, in consequence, greatly increased during the year and now occupies a large portion of the time at the disposal of many officers.

Since it will not be possible in future to export many eggs in shell, a considerable proportion of the surplus will be dried. During the year, an extensive programme of work on the storage of whole-egg powder was started in order to define the most appropriate storage conditions and the time elapsing before the onset of appreciable deterioration during storage.

The Council's Citrus Preservation Technical Committee is being disbanded. Since its formation in 1935, extensive investigations have been conducted under its guidance at four widely-distributed centres, and a valuable body of information is now available on the handling and storage of Australian citrus fruits. The results are being prepared for publication. The decision to disband was made because the problems of treatment and storage are now not so pressing as they were in 1935. The problems remaining to be solved have been more clearly defined, and it was felt that they could be readily attacked by the investigators at each centre without the guidance of a central committee.

Investigations throughout Australia on the handling, treatment, and storage of fruit, including citrus, will, in future, be co-ordinated by a special committee that is being formed from representatives of all bodies carrying out work in this field, including the Council, the Department of Commerce, and the Departments of Agriculture of New South Wales, Victoria, South Australia and Tasmania. Through the work of this Committee, overlapping of investigations will be avoided, and a valuable exchange of scientific data should result.

The work of the Division has again been greatly assisted by help in money, personnel, and facilities, that has been afforded by many outside bodies. The Botany Department of the University of Sydney has again made available several investigators for work on special problems in the storage of fruit.

A divisional publication entitled *Food Preservation Quarterly* is now being issued regularly. The scope of this publication includes articles in semi-technical language dealing with the handling, processing, and storage of foodstuffs, explanations of advances in technique, and reviews of progress in specific fields. Short accounts will also be given of the nature and scope of the work in progress in the laboratories of the Division, together with explanations of results of investigations already published. The quarterly is distributed amongst a wide field in the various branches of the food industries in Australia, and it is hoped that it will secure a more rapid application to industry of the results of the scientific investigations.

2. *Meat Investigations.*—(i) *At Brisbane.*—(*a*) *General.*—Work involving cool storage has been considerably interrupted due to alterations to the cold rooms and the surrounding structures, but opportunity has been taken, thereby, to carry out adjustments aimed at improving the performance of the system. The alterations have prevented a continuance of studies connected with the export of chilled beef, but it has been possible to carry out several other investigations of considerable importance to the meat industry.

(*b*) *Frozen Packaged Beef.*—Extensive investigations have been made on the problems arising in the preparation and transport of first quality boneless frozen beef, mainly for the use of the fighting Services overseas. Presentation of the meat in this form would not only save valuable freight space, but it would reduce the amount of preparation required in the field, as compared

with ordinary beef quarters. Preparations were made to forward an experimental shipment to the British Ministry of Food. Specific requirements included a package that would eliminate undue desiccation and freezer-burn, remain watertight upon thawing, and afford a safe-keeping time after removal from frozen storage, much longer than is the case with ordinary frozen beef, quarter or boneless. The only definite solution for the second condition was a tinned liner, the price of which was prohibitive commercially. The third factor of storage life is conditioned by the extent of the microbial contamination initially acquired by the beef, particularly during the process of boning out and packaging, as well as by the length of time that the beef is held after it is removed from frozen storage.

A considerable amount of work was done on the investigation of (i) the nature of the pack, to determine case sizes ; (ii) rates of freezing and thawing, at the geometric centre of the pack, for various types of cases, accompanied by bacterial counts before freezing and after thaw ; (iii) types of liners to be used in the cases to afford as near a watertight pack as possible ; (iv) microbiological conditions existing in the boning room. From the investigational point of view, the last two problems constituted the major difficulties.

On economic grounds it seemed desirable to use a wooden case, although the rate of freezing was not quite as favorable as with solid fibre-board. Every form of paper or other substance that could possibly be used as a liner to the case was investigated. Waxes designed to give smaller crystal size and greater plasticity were examined also. The shipment was made with wax liners, with a few liners of chlorinated rubber included. All the liners so far used have been made in the laboratory.

Hygienic conditions existing in the boning room were greatly improved as a result of the microbiological surveys. A special boning-out table was constructed for the purposes of this experimental shipment.

Objections laid down by the Department of Commerce to the severing of " cuts " were finally withdrawn. Without this concession, the packing would have been practically impossible owing to the multiplicity of case sizes necessary to handle the various cuts and wide range of body weights. As a result of much experimentation it was found possible to use a standard-sized case for the whole shipment. To satisfy the Department of Commerce on this point, an initial pack of 27 cases of boneless cuts of beef, derived from four bodies ranging from 680 lb. to 829 lb. was made, the average weight of contents of cases being approximately 56 lb. Following a period in frozen store the beef was shipped in November, 1940, and consigned to the Ministry of Food.

It is interesting to observe that, on the basis of the outside dimensions of the cases employed in the experimental shipment, the packaged meat occupied roughly 56 cubic feet per ton, contrasted with 90 to 95 cubic feet per ton of ordinary frozen beef. Actually 1 inch dunnage was used between layers. The volume per ton, therefore, would vary according to stowage. However, based upon 40 cases to the ton, each measuring 1 inch extra in height, the value would be approximately 61.5 cubic feet per ton.

Investigations into the question of suitable case liners have been advanced somewhat, chiefly in the testing of various types of waxed papers. A heavily-waxed kraft paper has been secured, which, while possessing marked mechanical advantages over all the other papers tried, was found satisfactorily water and drip-proof in small scale tests. Three packages such as those used in the 27 cases that were shipped, but employing this paper, were placed in frozen storage for test. Inspection was made of the packages after six and a half weeks' storage. The out-turn was very satisfactory, the " bloom " of the beef being extremely good, and the whole pack attractive in appearance. No tainting of the beef due to the liner was noticeable. However, leakage of drip from the beef was still a difficulty upon long-standing at temperatures just above freezing. In practice, little trouble is likely to be caused in this way, since the safe-holding period, microbiologically, sets a limit of three or four days, whereas breakdown causing leakage occurred later than this. To complete the initial order of 10 tons, a small supply of this special paper was recently made up at the mills and heavily waxed to specifications. An improved waxed chipboard was also evolved to enable satisfactory heat-sealing of the packages.

(*c*) *Interstate Chilled Beef.*—During the southern drought conditions in 1940, and the resulting heavy consignments of chilled beef from Queensland to the southern States, considerable complaint arose from various operators about the appearance at out-turn in Sydney of certain chilled beef from Brisbane. This laboratory had considerable discussion with interests representing both producers and operators ; as a result it made a preliminary survey of the problem.

Following a survey of conditions at this end, the Officer-in-charge of the Cannon Hill Laboratory inspected the out-turn at Homebush of beef which, in part, he had seen loaded in Brisbane. Causes of the bad out-turn complained of, arranged in order of importance, seemed to be—(i) method of unloading at Homebush ; (ii) carriage of the chilled beef stacked instead of hung ; (iii) condensation of moisture during transportation from abattoir to South Brisbane station ; and (iv) short-chilling of certain beef.

A full report covering all findings made during the investigation, together with recommendations, was prepared. Locally, every effort was, and is being, made to implement the recommendations contained in the report.

(*d*) *General Microbiological Investigations.*—The investigations on frozen packaged boneless beef presented a problem as to the viability of micro-organisms acquired in the boning room as a function of time of frozen storage. The investigation of this matter has so far yielded quite unexpected and valuable results. On the 20° C. counts, it appears that after 42 weeks of frozen storage, approximately 16 per cent. of the original population is still viable. The −1° C. counts show approximately 19 per cent. survivors for a period of 34 weeks. Plots so far suggest that the " kill " occurs in groups possibly according to the ability of the organism within a group to withstand conditions of its temperature environment. In other words it appears that resistance to the low temperatures varies among the contaminating organisms.

(*e*) *Co-operation with Industry.*—The laboratory has carried out a number of minor investigations and has answered many inquiries from the meat industry on such matters as transportation of frozen beef by rail, bacterial contamination of meat extract, the development of a reliable, rapid method for moisture determination in the extract, and the improvement in the hygienic conditions in chilling and boning rooms.

(ii) *At Sydney.*—(*a*) *The use of Ozone in the Ripening of Meat.*—The laboratory studies on the use of ozone in the ripening of beef have been completed and the results are being prepared for publication. The conclusion has been reached that ozone has little usefulness in this field, since concentrations of the gas that appreciably delay the onset of spoilage, at the same time bring about undesirable deterioration of the fat.

(*b*) *Canning Investigations.*—Meat investigations during this year have been chiefly in the canning field. In this connexion the Division has been called upon to assist the Defence Services Foodstuffs Committee in solving various problems encountered in the packing of service rations. In particular, the problem of black staining of canned meats and vegetables and their containers has been studied, and several methods of protecting tinplate from sulphide blackening have been tested. Certain locally-manufactured " sulphur-resistant " lacquers proved satisfactory for most products but not for sausages, since the lacquer peeled off and remained on the product after its removal from the can. At the present time, sausages can be successfully packed in lacquered cans only when certain imported lacquers of a novel type are used. However, lacquers of this type manufactured in Australia gave encouraging results in laboratory tests and are now being subjected to commercial trials.

A process for preventing black staining in food cans by forming an invisible protective film on the plate by immersion in a hot, alkaline, ozidixing solution has given particularly promising results. Treated cans in both laboratory and commercial trials remained free from black staining under the action of a variety of products, e.g., sausages, corned beef, meat and vegetable ration, tuna, crayfish, salmon, green peas, asparagus, sweet corn, French beans, cabbage, celery, pumpkin, carrots, parsnips, Brussels sprouts, Swede turnips, vegetable soup, and fresh cream. As a result of these tests, the so-called " oxide film " process has been included in defence services foodstuffs specifications as an alternative to internal lacquering for sulphur-staining products. The Division is now co-operating with several canning organizations in designing suitable plant for the large-scale application of the " oxide film " process.

3. *Preservation of Fish.*—(i) *Freezing and Cold Storage of Fish.*—A large-scale experiment with South Australian whiting has confirmed the results previously obtained with deep-sea flathead (*see* Annual Report 1939–40), but the susceptibility of whiting to " drip " loss during thawing was considerably less than that of flathead. In general, the safe storage life of whiting was longer than that of flathead, since the relatively low oil content of the former resulted in a less marked development of " off-flavours " which were found in the subcutaneous layer of flathead.

(ii) *Denaturation of Fish Muscle Proteins during Freezing and Storage.*—Reay's method, which involves the measurement of the solubility of the proteins in 1.0 M sodium chloride, has frequently been used for the estimation of denaturation of fish muscle. With the object of developing a more sensitive method, work has been carried out on the possibility of using the appearance of sulphydryl groups as an index of denaturation. A fairly satisfactory method has been evolved for the measurement of " reactive SH " values, but there are, as yet, insufficient data to indicate whether or not there is any correlation between these values and those for salt solubility. The method may not prove suitable for the measurement of changes in the proteins occurring during storage, for it is possible that progressive oxidation or some other change brings about the removal of the reactive SH groups as fast as they appear. Further work is being carried out on the applicability of this method.

(iii) *Smoking of Fish.*—The work in this field has mainly involved physical measurements, and it is, therefore, outlined in the report of the Physics Section (*see* below).

4. *Egg Investigations.*—(i) *General.*—The Council has continued to organize and direct the widespread investigations on the storage of eggs. During the year, extensive work was carried out in five centres, and two important causal factors in bacterial spoilage have been indicated. Further work is required to check these findings and to determine to what extent they may be responsible for the bulk of the wastage occurring under normal conditions of export to Great Britain.

Following the suggestion that the use of ortho-phenylphenol in fillers may greatly restrict bacterial wastage in stored eggs, experiments were carried out by the Council's investigators in Melbourne and Sydney using concentrations of the sodium salt of ortho-phenylphenol varying from 145 to 6,000 milligrams per filler. The latter concentration is considerably in excess of that which can be readily incorporated commercially. Although no tainting of the egg contents could be detected after storage up to seven weeks, no significant effect on wastage of the ortho-phenylphenol treatment was obtained, notwithstanding the fact that a high percentage of rotting due to *Pseudomonas* occurred in all lots.

A wide variety of shell coatings was tested at the Council's Sydney laboratory in order to determine their efficiency in the restriction of water loss by evaporation. The usual commercial method involved dipping in hot, medicinal paraffin, which gives a rather unsightly appearance to the shell. Coatings which were as efficient as the paraffin were also unsightly, while all the attractive and easily applied coats had a low efficiency.

An account of the bacteriological studies on eggs is given in the section devoted to micro-biological investigations.

(ii) *Dried Eggs.*—Although it has not been possible to carry out work on methods for the preparations of dried whole egg, investigations have been begun with the object of defining suitable standards of quality with respect to water content, reconstitution with water, colour, creaming, palatability, &c. These data will be of value to the Department of Commerce in framing the export regulations which will come into force when large-scale manufacture of the powder for export commences.

Since the dried egg powder must be carried overseas in unrefrigerated cargo spaces, and since there is evidence to show that fairly rapid deterioration occurs at elevated temperatures and in the presence of air (oxygen), extensive storage experiments have been commenced in order to determine precisely the period of storage elapsing before the onset of deterioration in quality. A range of constant temperatures and storage environments of air, and pure and commercial nitrogen, are being employed. The rates of onset of deterioration are being followed by physical and chemical methods and by standardized tasting tests by a panel of trained observers.

5. *Fruit Storage Investigations.*—(i) *At Sydney (in co-operation with New South Wales Department of Agriculture).*—(*a*) *Peaches.*—It has again been demonstrated that the storage life of the J. H. Hale variety is much longer at 30° F. than at 32° F., but the keeping quality of peaches is markedly affected by seasonal conditions during growth.

(*b*) *Plums.*—The technique of storing plums for 3 to 4 weeks at 32° F. and then slowly ripening them at 45° F. has been satisfactory for several seasons, but in 1941 unsatisfactory results were obtained by this method. Normal ripening occurred at higher temperatures and the temperature required for satisfactory ripening appears to depend on seasonal conditions.

(*c*) *Nectarines.*—Goldmine nectarines have been kept in a sound condition up to six weeks at 32° F. and subsequently ripened normally at atmospheric temperatures (65° F. approximately).

(*d*) *Pears.*—The Bosc variety again ripened with poor juice and flavour, and, although the reason for this is being investigated, the elimination of this variety from the list of exportable varieties must be considered. Its condition on ripening after arrival overseas has frequently been unsatisfactory. With the other varieties studied, a longer storage life was obtained at 30° F. than at 32° F., and the life in air storage at this temperature was equal to that obtained by gas storage at 32° F.

The Packham pear, which is the most widely grown variety in New South Wales, kept in good condition at 30° F. until the end of September and ripened with a good flavour and juice subsequently after removal to atmospheric temperatures. The effect of delaying Packham and Bosc pears at atmospheric temperatures prior to overseas export has again been investigated. A delay of four days at atmospheric temperatures had no harmful effect, but a longer delay decreased the available marketing life.

(*e*) *Apples.*—The effect of date of picking, storage temperature, and composition of the storage atmosphere on the keeping quality of Jonathan, Delicious, Granny Smith, and Democrat apples has been investigated. Three pickings of apples were made from orchards at Batlow and Orange, the second picking corresponding to the commercial picking date.

The keeping quality of the various varieties was related to the date of picking, and picking at the normal commercial time of Delicious and Democrat apples from both districts, and Granny Smith apples from Batlow, gave the most satisfactory results. The third picking of Granny

Smith apples from Orange was better than the other two pickings. Fruit picked earlier than the optimum stage developed bitter pit or superficial scald, while fruit picked later developed breakdown, mould, or late scald. There was no marked difference in keeping quality between the various pickings of Jonathan apples, and this result differs from that obtained in 1939. In 1940, each picking was made from different trees but, previously, portion of the crop was removed from the same trees at each picking time.

Very striking results were obtained with gas storage of Jonathan apples at 40° F.; fruit kept by this method was still sound in January, whereas comparable fruit kept in air at tenperatures from 32° to 37° F. had developed 10 per cent. wastage by July.

Delicious apples were more satisfactory at 32° F. than at 34° F., since the higher temperature caused greater wastage from mould and breakdown. Gas storage at 32° F. considerably reduced mould wastage in this variety but caused greater wastage from superficial scald.

In commercial practice, Granny Smith apples are usually delayed at atmospheric temperatures after picking to avoid subsequent development of superficial scald in cold storage, but last year's experiments indicated that better control of wastage and colour development was obtained by delaying the picking of the fruit. Sometimes this may cause loss through codlin moth, fruit fly, or hail injury, and the effect of coating fruit with a wax emulsion during the period of delay after picking is now being investigated.

For the later pickings of Granny Smith apples, a storage temperature of 32° F. gave better control of wastage from mould and late scald than a temperature of 34° F., but in the earlier pickings there was more wastage from superficial scald at the lower temperature. Granny Smith apples at 40° F. kept much better in gas storage than in air storage at the same temperature.

A storage temperature of 32° F. gave better results than 34° F. for Democrat apples, but the results of gas storage were variable.

There was a considerable increase in wastage in all varieties after removal of the fruit from cool storage to atmospheric temperatures, and wastage was due to superficial scald, mould, and breakdown.

(*f*) *Citrus Fruits.*—The controlling effect of sweating on subsequent rind disorders was further investigated with Washington Navel oranges from the Gosford district. The factors studied were rate and extent of moisture loss from the fruit, temperature and humidity conditions during sweating, length of sweating period, and the condition of the fruit at the time of picking. It seems that the effect of sweating is largely determined by the condition of the fruit at the time of picking, and sometimes sweating may actually increase subsequent rind disorders. In cases where sweating is effective, lateral spot can be controlled by holding the fruit for a certain time at high temperatures under conditions of high humidity, and a short period at 90° F. is as effective as longer periods at 70° F. The control of button spot is more difficult but can be achieved by holding the fruit for longer periods at high humidities or for shorter periods at low humidities.

A number of experiments have also been carried out to determine the relationship between temperature and the onset of rind disorders in Washington Navel and Valencia oranges. In fruit from the Gosford area, low temperature injury was avoided by storing Washington Navel oranges at 55° F. and Valencia oranges at 50° F., but satisfactory results were also obtained by holding the fruit at lower temperatures for short periods. The rate of development of rind disorders is lower at the lower temperatures, but the incidence of wastage at any cool storage temperature at a given time bears no relationship to the increased wastage which develops after removal of the fruit to higher atmospheric temperatures.

(*g*) *Protective Skin Coatings for Fruit.*—The effect of applying a protective skin coating of wax, oil, or shellac to the surface of various fruits has been investigated by this Division in co-operation with the New South Wales Department of Agriculture and the Botany School of the University of Sydney. The skin coatings are applied by dipping the fruit in a solution or a water-base emulsion of the various organic constituents. A technique for comparing the efficiency of various coatings on fruit has been developed, and the concentration of carbon dioxide and oxygen in the intercellular spaces of the fruit after treatment can now be determined.

Considerable time has been devoted to the preparation of colloidal wax emulsions that leave clear, bright films on drying. Only paraffin and beeswax are now available in Australia, and colloidal emulsions of these waxes have been prepared. The lowering of the interfacial tension between wax and water, and the ability of the emulsion to spread on the waxy surface of an apple, depend on the hydrogen ion concentration of the emulsifying agent. The effect of a skin coating is dependent on the nature of the constituents in the coating, the thickness of the coating, the class of fruit that has been treated, the temperature at which it is stored, and the maturity of the fruit at the time of picking.

A skin coating of wax or oil increases the resistance of the skin of a Granny Smith apple to the diffusion of oxygen but has little effect on the resistance of the fruit to the diffusion of carbon dioxide. A skin coating of shellac, however, has a marked effect on the diffusion of carbon dioxide. Skin coatings delayed colour development and the onset of ripeness in Granny Smith apples and gave results with Jonathan apples as satisfactory as those obtained by gas storage. The storage life of William pears was considerably increased and the ripening of plums and peaches delayed. Moisture loss in apples, pears, peaches, plums, and oranges was also considerably reduced.

The results in refrigerated and unrefrigerated storage are promising, and comprehensive investigations are in progress, but in some cases alcoholic flavours and serious internal disorders such as core flush, breakdown, and brown heart will develop if the storage period is prolonged. The development of brown heart under conditions of oxygen deficiency without excess carbon dioxide is interesting, as this disorder has usually been associated with high carbon dioxide concentrations.

(*h*) *Chemical Work.*—Studies of the changes in the natural waxy coatings on fruit are in progress, and attention is being given to the problem of the development of off-flavours in orange juice after extraction.

(ii) *In Melbourne* (*in co-operation with Victorian Department of Agriculture*).—(*a*) *Apples.*—In 1940, eight varieties of apples were held at 34° F. and 40° F. in air and gas storage. The artificial atmospheres used varied in composition from 5 per cent. carbon dioxide, 16 per cent. oxygen, to 5 per cent. carbon dioxide, 5 per cent. oxygen. Gas storage was found to delay colouring and ripening in every variety, particularly in atmospheres containing only 5 per cent. of oxygen. The effect, however, varied considerably with variety. The best results were obtained with Granny Smith and Ballarat apples, which, after eight months' gas storage in 5 per cent. carbon dioxide, 5 per cent. oxygen, were just as firm and green as when picked. Gas storage also delayed ripening considerably in London Pippin and Rome Beauty apples, but was responsible for superficial scald in the former and internal breakdown in the latter variety. Ripening and subsequent loss of quality in Jonathan, King Cole, Delicious, and Democrat apples was only slightly delayed by gas storage, and the Jonathan and Delicious apples developed brown heart when the oxygen content of the atmosphere was reduced to 10 per cent. or less. The most outstanding effect of gas storage on Jonathan apples is the complete control of Jonathan Spot which has been obtained in five seasons.

Comprehensive experiments were carried out on the development of breakdown in Jonathan apples and bitter pit in Granny Smith apples. The factors of maturity, size, temperature of storage, and delayed storage were all investigated. However, the incidence of these disorders was comparatively slight in the last season, and no conclusive results were obtained. A considerable development of breakdown was obtained in a small trial in a practically saturated atmosphere.

(*b*) *Pears.*—Gas storage of pears at 32° F. in an atmosphere containing 5 per cent. carbon dioxide and 16 per cent. oxygen has increased the storage life by 100 per cent. in the Williams Bon Cretien, Bosc, and Winter Cole varieties, 30 per cent. in the Packham and Winter Nelis varieties, and less than 10 per cent. in the Josephine variety, as compared with air storage at the same temperature. One atmosphere, 10 per cent. carbon dioxide, 11 per cent. oxygen, has sometimes increased the storage life still further, but in other cases has brought about internal injury (" hard heart ").

(*c*) *Grapes.*—Several chemical treatments for control of mould wastage in stored grapes have been investigated, and the best results have been obtained by placing a tablet containing 15 per cent. of sodium bisulphite and 4 per cent. of spermaceti with each bunch in the paper woodwool pack, or by treating the granulated cork used for packing with about 2.5 grammes of iodine per pound of cork. Both these treatments practically doubled the time required for appreciable development of mould at 32° F. Treating the cork with the sodium salt of ortho-phenylphenol also delayed the development of mould.

6. *Fruit Products Investigations.*—(i) *Apple Products.*—Investigations into the canning of apple juices were extended to cover some 15 commercial varieties from New South Wales, Victoria, and Tasmania. The general processing method adopted was that previously described, and the juice was bulk stored in carboys as before. Facilities were recently made available for storage at reduced temperature under high pressure of carbon dioxide.

A wide blending programme was completed with juice from the 1940 season. It was found that each of the varieties, French Crab, Sturmer, and Scarlet, provides a suitable base for commercial production, though the addition of a small quantity of an aromatic juice to increase flavour intensity is desirable. Jonathan, Granny Smith and Delicious were found to be useful for this purpose.

Particular attention was paid to methods for ensuring maximum clarity in the canned or bottled product. Treatment with commercial pectolysing enzymes, followed by filtration in which a silicious filter aid was employed, was found to give a satisfactory product. Best results were obtained by frequent stirring of the bulk after the addition of the correct quantity of activated enzyme. The clarification process results in a marked reduction in flavour, which does not appear to be fully offset by the improved appearance of the juice. Cloudy apple juices prepared in the laboratory were found to possess high flavour intensity, and they warrant consideration as marketable products.

Several experimental batches of apple butter were manufactured with a view to supplying from Australia the requirements of the Dutch East Indies. Formulae were available from American sources, and the final product, although of good quality, was found to differ considerably from the Dutch product in flavour, colour, and texture. Further investigations are in progress.

Concentration work with fruit juices has been limited in extent, but it is anticipated that the installation of additional equipment will permit it to be expanded shortly. Working with a pilot plant of the climbing film type, concentrated apple juice was produced from depectinized, stored juice. The product tended to be flat in flavour when reconstituted with water, but appears to form a useful fruit base for cordials and carbonated beverages. Concentrated apple juice is a stable product and may be stored without the difficulties usually associated with normal juice. Apple treacle was also produced by concentration of the partially depectinized juice. It seems to offer commercial possibilities as an alternative apple product.

The preparation of syrupy pectin concentrates from apple pomace was commenced with the object of assisting actual and potential producers in Australia. A number of samples were manufactured but owing to pressure of work in other directions it was found necessary to discontinue this avenue of investigation.

A varietal survey of Australian apples suitable for alcoholic cider production has been commenced. Cultures of wine yeast of the champagne and Pinot-Madeira type were inoculated into juices and fermentation allowed to proceed under controlled conditions. Sweet, medium dry, and dry ciders with sulphur dioxide as preservative are at present undergoing maturation.

The question of preservative in alcoholic ciders has been given some consideration owing to variation in quantity permitted by the various State authorities. Experimental work designed to test the effectiveness of differing concentrations of sulphur dioxide in preserving ciders of varying alcohol content is well advanced, and the conclusions reached will be published shortly.

(ii) *Pineapple Juice.*—Smooth Cayenne and Common Rough pineapples from Queensland were used throughout the season. A pleasant juice was prepared by blending 10 per cent. of Common Rough with Smooth Cayenne. Investigations into the clarification of pineapple juice were continued, and it was found that brilliant filtration is wholly undesirable, since the greater part of the flavour is removed in the process. On the other hand, the addition of screened pulp gave an attractive full body to the product. Losses of fruit during transit suggest that pineapple juice should be produced in close proximity to the source of supply.

(iii) *Citrus Juices.*—Investigations were continued with Washington Navels, Parramatta and Valencia oranges, lemons, and grapefruit. Juice from Washington Navels at all maturities was bitter and unpalatable, whereas Parramatta oranges again gave a pleasing product when picked at the correct stage of ripeness. Grapefruit and lemon juices were of good quality, the latter showing practically no reduction in flavour after prolonged storage.

The method of de-aeration was tested by determining residual oxygen in juice after different rates of flow, temperatures, and absolute pressures in the de-aerator. Increase in juice temperature is an important factor in de-aeration, but is limited in the higher temperature range by excessive loss of volatile flavouring constituents. Rate of flow is also of importance up to the point of obtaining sufficient impact against the side of the vessel. Beyond that point efficiency falls off with volume increase. For the type of de-aerator used, it was found that, at an absolute pressure of 2 inches of mercury, the optimal temperature and flow rate were 72° F. and 180 gallons per hour respectively.

The role of oxidative rancidity of the fat fraction of orange juice in development of stale flavour during storage is under investigation. The work has been undertaken following a report by Nolte and von Loesecke concerning the physical and chemical characteristics of the petroleum-ether-soluble material of fresh and canned juice.

(iv) *Passionfruit Juice.*—Juice was prepared by scooping pulp from cut halves and brushing through a 12-mesh sieve. An equal quantity of water was then added and the high acidity offset by the addition of cane sugar. The bulk was then flash pasteurized at 190° F., cooled to 170° F., and canned. Dilution of the natural product was found necessary owing to viscosity increase during passage through the pasteurizer. Sweetened and unsweetened pulps were preserved by vacuum sealing and immersing the cans in water at 212° F. for 30 minutes. Seedless

sweetened pulp similarly prepared forms a natural concentrate by reason of its high acidity and intense flavour. The flavour, aroma, and general palatability of all passionfruit preparations were found to be excellent after six months' storage.

(v) *Grape Juice.*—Four varieties were used at Homebush, and the procedure was essentially that previously described. The method of extracting colour from the skins of black grapes was varied. It was found that immersion of the grapes for four minutes at 200° F. caused the skin pigment to diffuse inwards through the flesh to a depth of approximately $\frac{1}{8}$ inch. Juice from grapes treated in this manner was satisfactorily coloured and free from cooked flavour. Immersion for periods in excess of four minutes and at higher temperatures caused the fruit to burst. The earlier method of preheating the grapes to 170° F. before pressing was less effective in extracting colour, and signs of cooking were detectable.

Black and White Muscat juices were superior to those from other varieties. In all cases the importance of picking maturity with respect to flavour retention was demonstrated. A varietal survey at Roseworthy Agricultural College was responsible for the accumulation of valuable data which will be published shortly.

(vi) *Tomato Juice.*—Seven varieties of tomatoes have now been tested for suitability for juice production, and confirmatory evidence was forthcoming as to the superiority of the Marglobe. Reduction in particle size by passage through a 12-mesh and 30-mesh sieve was found to provide a reasonable substitute for homogenization. Tomato cocktail prepared according to an American formula was found to be appetizing, and attention is drawn to its possibilities as a commercial product in Australia.

(vii) *Prune Juice.*—Hall-marked D'Agen prunes C-grade 60–70 of 1940 season were used for the preparation of juice by the disintegration and diffusion battery processes. Equipment for the latter process was donated by the New South Wales Dried Fruits Board, and juice so prepared was shown to be superior to that obtained by the disintegration method. To improve the palatability of the products, two blends were prepared, viz., prune juice with lemon, and prune juice with lemon and passionfruit. The blends were found to give a much superior product. Experimental work with the Robe variety has not yet commenced.

(viii) *Miscellaneous.*—During the year, a wide variety of fruit, meat, fish, and vegetable products were canned, chiefly with the object of demonstrating the utility of the oxide process and internal lacquering in avoiding disabilities that occur in the unprotected can. A striking series of canned black and white cherries demonstrated the necessity of employing protective lacquer coatings for pigmented fruit and vegetable products. Information so gained has been extended to food canners by correspondence, by direct contact, and through the medium of the Division's Food Preservation Quarterly.

General advisory work has also been extended and now forms a major part of the activities of this laboratory. A considerable number of commercial samples have been submitted for physical and chemical examination, and appropriate corrective measures recommended where possible.

The testing of apple juices and ciders under the Australian Apple and Pear Board certification scheme commenced in October, 1940. The work involves periodic analyses with the object of assisting in the maintenance of a high standard of quality in commercial products. The most noticeable faults to date have been a tendency to overheat during pasteurization and lack of balance between acid and sugar in the juice. A number of personal visits have been made to factories during the year with useful results.

An important aspect of the canning preservation work has been to survey the field for useful sources of vitamin C, having particular reference to war-time nutritional requirements. The citrus juices, which are well known to possess high antiscorbutic potency, have been shown to lose very little of their value during processing treatment and after several months' storage. The use of sodium benzoate as preservative apparently exerts no detrimental effect on the vitamin, but the position with regard to sulphur dioxide is at the moment somewhat obscure. Orange juice concentrated six times by rapidly boiling under atmospheric pressure was found to lose very little ascorbic acid, possibly due to the blanketing effect of the steam. When concentrated more slowly, a greater percentage loss was sustained, but the product may still be regarded as a valuable vitamin concentrate. Concentrated orange juice so prepared is somewhat bitter, but, on dilution, the beverage is quite palatable.

Tomato juice extracted from preheated fruit was found to possess approximately one-half the vitamin C potency of orange juice, and the figure for passionfruit juice undiluted was almost identical with that from tomatoes. The vitamin content of some local and imported commercial lime juices preserved with sulphur dioxide was found to be very low by comparison with that of fresh juice.

A series of ascorbic acid determinations on lemon juice from silver-ripe, tree-ripe, and ethylene-ripened fruit was made, and results indicated no significant differences between treatments.

Lacquer investigations have been continued throughout the year, and more recently an investigation of appropriate materials for the substitution of tinplate has been commenced.

7. *Microbiological Investigations.*—The principal studies have been on problems of the bacterial wastage in eggs as part of the general programme directed by this Council and the Egg Producers' Council. The Council's investigators have been largely responsible for the direction and execution of the rather heavy programme of egg storage experiments in New South Wales and Victoria and, of necessity, these activities have decreased the time available for purely bacteriological studies. Investigations on mould wastage in apples have been continued on the 1940 crop, and the most important types causing wastage have been isolated. Other investigations commenced and in progress are the control of fermentation in apple juice by sulphur dioxide, and certain minor investigations into the microbial content of dried egg products and spoiled canned foods.

(i) *Egg Investigations.*—(*a*) *At Melbourne.*—The classification of bacteria isolated from egg rots has been continued. The most important types are *Pseudomonas* spp.; but species of *Proteus, Achromobacter*, and some coliform types are also of significance. The inoculation of eggs by immersion in suspensions of bacteria has shown that the incidence of rotting decreases rapidly as the interval between laying and immersion is increased. This finding is in agreement with recent English work which showed that the immersion of eggs in bacterial suspensions results in heavy wastage when the eggs are appreciably warmer than the liquid in which they are immersed. The effect is presumably due to the suction produced when the egg contents contract after cooling in the liquid suspension. The practical significance of these results has been indicated in other experiments in which wastage was enhanced by washing eggs soon after laying.

Further experiments in inoculation of eggs by immersion in bacterial suspensions have measured the time required to produce rots and the bacterial contents after fixed periods of storage. The eggs for these experiments were obtained from single pens of White Leghorn fowls. The results give some indication that large bacterial populations develop more rapidly in the eggs produced by some of the birds; in other words, these eggs are more "susceptible". The variability of the results has, however, been high, and the point warrants further investigation.

Studies on the microflora of egg shells have shown that passage of the eggs over certain cleaning machines has resulted in considerable increases of the Gram-negative organisms on the shell. As the organisms isolated from rots are almost exclusively Gram-negative, these findings are of some interest. The changes were greatest when clean eggs were machine cleaned, but significant increases in the relative incidence of gram-negative types were also observed when soiled eggs were cleaned by machine. In these experiments the machines were carrying high numbers of gram-negative bacteria and were in fact acting as reservoirs of infection which was gradually transferred to eggs passed over the machine. The relation of these findings to the influence of machine cleaning on wastage is still uncertain.

Owing to the resignation of the bacteriologist stationed in Melbourne, these studies have been temporarily discontinued until a further appointment is made.

(*b*) *At Sydney.*—Bacteriological examination of eggs collected from a farm which had been producing eggs of poor keeping quality showed that rotting of the eggs occurred to a large extent (82 per cent.) when the eggs were cleaned on the farm by using a certain commercial machine. Eggs washed by hand at the laboratory and clean eggs unwashed when stored under the same conditions showed very low wastage (1 per cent. and 2 per cent. respectively). In unwashed eggs bacteria could not be demonstrated in any of 50 eggs when the contents were inoculated into a variety of media.

For the machine-cleaned eggs, the percentage of eggs in which it was possible to demonstrate bacteria by cultural methods increased with the duration of storage. It is not known whether this is due to delayed penetration by the bacteria or to the difficulty of detecting very small numbers of bacteria within an egg.

(ii) *Mould Wastage in Apples.*—A survey of the mould wastage in cold-stored apples from the 1940 crop has been conducted in New South Wales. Results for the year showed that mould wastage was substantially higher in all varieties harvested at Batlow than in those harvested from Orange. For all varieties from both districts mould wastage increased as the time of picking was delayed. The most important agents of wastage were *Penicillium* sp. (probably *P. expansum*) *Gloeosporium* sp., and *Botrytis* sp. (probably *B. cinerea.*)

Penicillium sp. was the commonest cause of wastage in all varieties, but its incidence was highest in the Granny Smith variety. This fungus was also particularly important in the Democrat variety. Wastage due to *Gloeosporium* sp. was also high, particularly in the variety Delicious in which it was probably the factor limiting the storage life of the fruit. Infection by this fungus was also severe in Jonathan but less important in Democrat and Granny Smith varieties. *Botrytis* sp. was of less importance than the other two pathogens. It was apparently most serious in the variety Granny Smith, although it was recorded in all varieties stored.

By the method of plate exposures, a survey of the fungal flora existing in the atmosphere of an orchard and packing shed in the Orange district was made early in 1940. Inoculation of apples demonstrated that many of the types found were capable of producing rots. The quantitative assessment of the importance of these air-borne types in commercial mould wastage is, however, uncertain.

Certain measures for the control of fungal wastage in apples are being tested during the present season. Further experiments in co-operation with the Department of Botany, University of Sydney, are now in progress ; in them the effects of variety, district, and time of picking are being measured in terms of the rate of growth of fungi inoculated into apples of the 1941 crop.

(ii) *Preservation of Cider.*—The amount of sulphur dioxide required to prevent fermentation in apple juice and cider has been shown to decrease with increasing alcohol content. The limiting values necessary for preservation at various levels of alcohol content will shortly be published.

8. *Physical Investigations.*—(i) *General.*—As in previous years, a large proportion of the time of the Physics Section has been devoted to the maintenance and running of mechanical equipment, the design and construction of apparatus, the statistical analysis of experimental data, and the design of experiments, and to collaboration with other sections on various problems.

(ii) *Evaporation of Water from Oranges.*—Continuing work reported last year, it has been shown that there may be a large increase in the rate of evaporation due directly to the effect of machine-handling in ordinary packing-shed processing of oranges. Only one machine has yet been studied in detail, but others will be tested during the coming season. With the machine used in 1940 it was shown that the increased rate of evaporation was due almost entirely to the effect of the scrubbing brushes.

(iii) *Cooling of a Wet Body.*—Work on this problem has been continued and considerable progress has been made.

(iv) *Permeability of Wrapping Materials to Water Vapour.*—The method of measurement used previously in this laboratory has been modified slightly. Measurements have been made on each of a fairly representative selection of the materials available. A note on this work has been published in the Council's Journal.

(v) *Smoke Curing of Fish.*—A series of experiments is being carried out in co-operation with the Fisheries Division using a specially designed kiln in which the temperature and humidity of the air can be controlled. The work is aimed at determining, among other things, (*a*) optimum physical conditions for the smoke curing of several species of Australian fish ; (*b*) upper limits of temperature and humidity in kilns for satisfactory curing ; and (*c*) possible inexpensive methods of reducing difficulties due to unfavorable climatic conditions.

(vi) *Freezing of Fish.*—A survey of methods in use in several centres has been carried out, and a note on methods of freezing and storage, and of handling before freezing has been prepared for the information of interested persons.

(vii) *Drying of Foodstuffs.*—The Section has collaborated with the Commerce Department's engineer in his survey of equipment and methods for drying foodstuffs.

(viii) *Wrapping of Frozen Pork Legs.*—In the frozen storage of pork legs, a common trouble is the formation of " freezer-burn "—discoloured patches, caused by desiccation. It has been demonstrated that a sealed wrapping that has a very low permeability to water vapour is effective in preventing " freezer-burn " of pork legs. Sealed wrappers of ordinary materials which have greater permeability to water vapour reduce " freezer-burn ", but they are not so effective and reliable as a material of very low permeability which allows a good seal to be made.

IX. FISHERIES INVESTIGATIONS.

1. *General.*—To meet the demands made by war conditions, certain modifications were made in the Division's programme of investigations with a view to intensifying activities likely to promote a greater production of marine products. Work on fundamentally important problems, such as changes in oceanographic conditions, was reduced to a minimum consistent with maintaining continuity. Virtually the total time of the research vessel was devoted to attempts to solve the problems of bringing the pelagic fishery to the commercial stage. Developmental work was also intensified over the whole available field, with particular success in the instance of fish oil production, which for the first time in Australia has assumed the proportions of an industry ; and with promising results in the case of seaweed utilization.

Commercial tests of the trolling method for tuna are being carried out by two vessels operating under a protective guarantee. Further experience gained during the year has, however, disclosed that mass-catching of tuna by the live-bait method cannot be undertaken until a regular supply of live-bait can be assured. Owing to the proved sporadic occurrence of pilchards and anchovy in surface waters, this can apparently be done only by providing a system of penning,

now being considered. Promising results were obtained in the ring-netting of pilchards and sprats, and the research vessel has been equipped with the range of specific types of nets now shown to be necessary for making definite tests in the capture of pelagic fish under the peculiar conditions prevailing in Australian waters.

2. *Technological Investigations.*—A considerable increase in advisory work has developed, and the trade has been in close touch with the Division concerning canning and smoking methods, fish oil production, and other matters.

A trade circular—*The Canning of Fish and Fish Products in Australia*—and an article on the same subject in the Council's Journal, have been published. These summarize overseas literature on fish canning, and describe experiments and methods used in the translation of overseas practice to Australian conditions. Still later work has shown the potentialities of the mackerel and the Tasmanian sprat as substitutes for herrings and sild respectively. It has in general been shown that high quality canned products can be obtained using Australian species of fish. The need of such products to replace imports is urgent.

Studies on the smoking of fish have been continued in conjunction with the Division of Food Preservation. A trade circular on this subject has been issued, and blueprints and specifications of a satisfactory type of smokehouse are available. An air-conditioned drying unit and kiln has been constructed, and preliminary observations have been made therewith. It has been found possible to control the temperature and humidity during the smoking process and to study some of the essential factors for preparing a satisfactory product. It is believed that the results obtained from this kiln will simplify the smoke curing of fish under difficult external conditions of temperature and humidity. Attempts to smoke mullet and mackerel to provide a substitute for bloaters have not been altogether satisfactory, as the flavour is not so intense. Owing to the shortage of imported fish, manufacturers of pastes are recommended to produce substitute Australian lines.

Fish liver oil production has been studied, and as a result of the impetus given to this work a considerable quantity of medicinal fish oil is now produced in Australia. Studies on the production of suitable oils for medicinal and stock-feeding purposes are continuing. Tuna liver and mullet viscera oils have been produced on a semi-commercial scale by satisfactory methods. The vitamin content of these and other oils is being assayed by the Commonwealth Serum Laboratories. It has been found that the soda process is best for recovering the oil from Australian teleost fishes, though steam alone is sufficient for rendering shark and other Elasmobranch livers. Bluefin tuna requires an oil-in-oil extraction as well as soda digestion. The most promising results were obtained from livers of *Seriola grandis* (kingfish or yellowtail of New South Wales), which gives a high yield of high vitamin potency oil, but which is unfortunately not caught in large quantities. This fish smokes well and cans fairly well.

Bacteriological work has of necessity been reduced, but work is proceeding on a study of the effect of slime on the keeping of fish. This is not a simple problem, and more work is required for a final solution. Under the conditions of experiments made to date, there seems to be no significant difference between keeping qualities of washed fish and fish with the slime left on. The study of the effect of gutting on the keeping of fish is part of the same programme. Studies have been begun to determine whether " winter mortality " of oysters is a bacteriological disease. This work is in its early stages, and with the last mentioned research is part of a programme of co-operation with the State Fisheries Department of New South Wales.

Considerable attention has been devoted to the possibility of agar production in Australia, with promising results. In 1938, imports of this material were 160,000 lb., valued at between £25,000 and £30,000, all from non-sterling countries. At the present time the value would be much higher, since agar is quoted at 17s. 6d. per lb. In response to an appeal from the Medical Equipment Control Committee, the Division undertook to supply the pathological requirements of Australia, if this were necessary. A process of manufacture has been worked out which gives a very good quality product, suitable for pathological and commercial requirements. Surveys have been made which show a reasonable supply of *Gracilaria* in accessible areas, but it is not yet definitely known whether a regular supply could be obtained in quantity to satisfy Australia's needs. This seaweed is suitable and occurs on sandy beds. Harvesting methods are being tried, though it is credibly reported and to some extent already confirmed that *Gracilaria* is washed up on the beaches in quantity in late winter and early spring. If such occurrences are regular and can be expected each year, there should be no difficulty in establishing an agar industry in Australia.

Species suitable for agar production if they can be harvested reasonably and in sufficient quantity include *Gracilaria confervoides* (Port Hacking and Bateman's Bay, New South Wales, and Swan River Estuary, Western Australia), *Eucherima speciosum, Rhabdonia robusta*, and *Gracilaria furcellata* (Leighton, Western Australia), *Gracilaria lichenoides* and *G. furcellata* (Tasmania, Bateman's Bay, and Cronulla, New South Wales).

3. *Tuna Investigations.*—The original programme of scientific investigations into the characteristics of the Australian tunas has been carried on during the year without serious modifications, and some additional lines of inquiry have been incorporated. The sampling of the stocks of southern bluefin (the most important commercial species at present) has been energetically extended, and measuring programmes are now under way not only on the research ship *Warreen* but at the canneries and on certain fishing boats. Co-operation has also been received from big game anglers in South Australia, through Mr. K. Sheard of the South Australian Museum. Special attention has been given to the important problems of fluctuations and relative abundance. A system of log-books has been initiated for the use of troll fishermen, and it is expected that useful data on relative abundance, as between season and season, and between the various fishing areas, will be forthcoming to supplement the work of the *Warreen* in this respect.

Experiments in practical fishing methods by the *Warreen* have been mainly directed to live-bait fishing, and the results to date have shown clearly that the problem resolves itself into one of the capture and transport of the bait fish. The matter is discussed in some detail in the report on Clupeoid investigations, but it may be emphasized here that the main potential bait (pilchards) are much more difficult to catch regularly in south-eastern Australia than in California—the typical area for this method of tuna fishing.

The only practical method as yet established is trolling. From evidence available to the Division it appears that this method is economically sound for small vessels on the south coast of New South Wales in the spring months, but the yield by trolling in the Tasmanian region appears to be rather too low to be consistently profitable. Unfortunately, however, owing to a combination of causes, trolling on a commercial basis has not yet been established on the New South Wales coast. Uncertainty of an assured market for the processed tuna held back the canneries from extensive packing, and when, through the direct efforts of this Division, military contracts had overcome this difficulty, lack of boats and also refrigeration facilities acted as handicaps.

In later summer and autumn of 1941, unusually large quantities of the northern tuna (*Kishinoella tonggol*), which had been regarded as an inhabitant of the waters to the north of Sydney, were reported as far south as Merimbula, towards the Victorian border. It appears, however, that this is more or less of a normal occurrence, but in 1941 the tuna may have been exceptionally abundant. Commercial catches were made at Port Hacking, Jervis Bay, and Merimbula, and full opportunity was afforded the officers of this Division in making biological and technological investigations. The species takes the hook but rarely, and most catches were made by beach nets.

4. *Clupeoid Fish Investigations.*—The principal lines of investigation continue to relate to distribution, size, chemical composition, maturity, &c. A full account of the work done up to February, 1940, with a summary of later work up to November, 1940, has been published as the Council's Bulletin No. 138.

(i) *Pilchard* (*Sardinops neopilchardus*).—Shoals of spawning non-oily fish, of average length about 6 inches, were abundant as usual off the New South Wales coast between April and September, 1940, and were again upon the coast at the same season in 1941. Of outstanding importance was the finding during 1940 that there was an extension of the New South Wales pilchard season, in respect of small fish only (2 to 4 inches), from September to December. These latter fish could thus be used as live-bait for bluefin tuna, which occur in some at least of the same waters at the same time. Tests carried out on the research ship showed that these pilchards can survive long journeys in bait tanks aboard fishing craft (two lots were carried at different times for nine days, from Jervis Bay to southern Tasmania, and liberated in good condition), and that they are acceptable to the tuna as bait. There are accordingly good prospects of penning this fish for bait supply. Together with anchovy, the pilchard would appear to provide possibilities of an all the year round bait supply on the New South Wales coast.

The main obstacle to the exploitation of pilchards for live bait and canning is the difficulty of capture. The lampara net, a type of surface seine very successful in the Californian and Mediterranean pilchard fisheries, cannot be depended upon to secure fish in the day-time; its performance at night is perhaps a little better, but shoals are much less frequently seen at night than in the day-time. In fact, intervals of many days occur between their appearances near the surface. It is hoped that the purse-seine, or some modification of it, may prove suitable for catching pilchards in quantity, and tests are being undertaken.

Pilchards were noted in Tasmanian waters for the first time during these investigations. They were present off the south-eastern coast of the island between January and May, 1941. These fish seem to belong to the same population as the South Australian and Victorian fish, which spawn in summer rather than in winter as the New South Wales and Queensland pilchards do.

(ii) *Sprat* (*Clupea bassensis*).—Our knowledge of this fish has been considerably increased. Numerous shoals of this species, whose average length is about 4 inches, were found in the d'Entrecasteaux Channel, near Hobart, in May and June, 1940, and in March, April, and May, 1941. Some good hauls of up to two and a half tons apiece were made with the lampara, but generally speaking this net seems as unsatisfactory for these fish as for the pilchard. It is, therefore, being replaced by a small ring or purse-seine net. Tests made indicated that the sprat is unsuitable for live bait, since it dies quickly in the bait tanks and even in the wells of small boats. It could, however, be of importance for canning. The species seems to be confined to Tasmania.

(iii) *Southern Herring* (*Harengula castelnaui*).—Further investigations tend to confirm the view that this species is present in the bays and estuaries of northern New South Wales and southern Queensland at all times of the year. Although probably there are insufficient quantities to sustain canning operations, the species could contribute a portion of cannery supplies.

(iv) *Anchovy* (*Engraulis australis*).—Anchovies were not apparently as abundant as usual on the southern coast of New South Wales during the summer of 1940–41, although results in other years had indicated this as the best season of the year for this species for those waters. Peak seasons in other waters are so far undetermined.

(v) *General.*—During April, 1941, all the fishing ports of northern, eastern, and southern Tasmania were visited by a land party, and inquiries made as to the distribution of Clupeoids. The results support the experience of the research ship over the past three years, viz., that apart from the sprats these fishes are not markedly abundant in Tasmanian waters, pilchards and anchovies being only sporadic in occurrence. Since, as we have already seen, the sprats are useless for live bait, it must be concluded that any Tasmanian tuna fishery depending on the live bait technique will have to depend largely at any rate on bait fish carried alive from New South Wales or other waters. In New South Wales, on the other hand, supplies of suitable live bait (pilchards, and sometimes anchovies), would be available in the tuna seasons in the same waters.

5. *Mullet Investigations.*—The investigations on the mullet, *Mugil dobula*, have embraced racial, maturity, " condition ", growth, and age-composition studies, together with a study of the course of the fishery. A preliminary report has been prepared and submitted to the Fisheries Departments of the States concerned.

On biological evidence it appears (*a*) that there is along the eastern coast one continuous intermingling stock occupying estuarine and oceanic waters in separate phases (this conclusion was based on racial studies and the results of tagging operations) ; and (*b*) that the fish mature at the end of their third year, when the average length is approximately 33 cms. (almost 13 inches).

The examination of marketed mullet (by measurements) of statistics available, and of fishing operations, led to the conclusion that depletion existed to a serious extent in Western Australia and was present, although to a lesser extent, in eastern Australian waters. On the basis of these conclusions it was suggested that protection should be given to immature stock by means of an increase in minimum legal size. Thus the necessary temporary reduction in catch would be secured equitably, while adequate stock recruitment, together with increase in size of fish caught, would also result. It was also recommended that alterations of the restrictions on gear should be made. Organization of statistical systems was urged so that the effect of the altered minima might be observed. Should these steps fail to restore the fishery, the statistical system would provide data for the formulation of further restrictive measures.

These suggestions have been discussed in several conferences between the Division, the officers of the various Fishery Departments, and members of the fishing industry. An account of the work has been given in an illustrated brochure printed by the New South Wales Fishing Industries Association, and distributed to the fishermen. Steps are being taken to implement the proposals.

The systematic revision of the Australian mullets is proceeding, and the biology of other species (principally of *Agonostoma forsteri*, *Myxus elongatus*, and *Liza argentea*) is being investigated by the collection of data on growth, &c.

6. *Salmon Investigations.*—Work conducted in New South Wales and Victoria served to substantiate and elaborate the results of earlier work. The analysis of length frequency figures. biological data, and of a large series of scale-age readings, indicates that the " vulnerable " age of the salmon in New South Wales is from 5 to 9 years, and in Victoria from 3 to 7 years.

The investigations in Tasmania, very intermittent until February, 1941, but recently intensified, have yielded much valuable information, particularly data relating to the early life history, and have thrown new light upon the seasonal movements of the fish. Recent observations have confirmed the earlier impression that northern and eastern Tasmanian waters form a nursery ground for large numbers of juvenile salmon, and samples of fish of 1 + and 2 + years of age have been obtained.

Further data concerning the feeding habits and spawning periods are being compiled, and precise biological investigations are progressing, aimed at establishing the validity or otherwise of the previously formed impression that two separate stocks inhabit the eastern waters of Australia. The actual spawning areas of the Australian salmon, the characters and zones of occurrence of the larvae, and the period of larval development have yet to be disclosed.

7. *Barracouta Investigations.*—In Australian waters, the greatest concentration of barracouta appears to be in Bass Strait and along the eastern coast of Tasmania. Evidence previously obtained, and substantiated by later information, reveals that these areas, as for the Australian salmon, are important nursery waters. Juvenile barracouta from $1\frac{1}{2}$ to 3 inches in length have been obtained in fairly large numbers from the stomachs of tuna and adult barracouta captured in the Cape Pillar area, and large barracouta from the northern waters of Tasmania have been found to contain in their stomachs members of their own species up to 9 inches long. Biological investigations reveal that the spawning season extends from November to March, and the spawning grounds appear to cover an extended area along the eastern coast of Australia.

The scales of the barracouta have proved useless for age determination, and the otoliths are apparently not thoroughly reliable. Length-frequency figures indicate that the age of the barracouta taken in the fisheries extends from 3 to 7 years.

8. *Oyster Investigations.*—(i) *General.*—A statement of the present condition of the Australian oyster industry and of the biological problems involved in the various operations of oyster cultivation has been published in the Council's Pamphlet No. 105. On the basis of this statement, suggestions have been made to the New South Wales State Fisheries Department, as to steps which might be taken immediately towards effecting some improvements in the industry. Some of these suggestions have been accepted.

(ii) *Spat-fall.*—Confirmation was obtained in the course of field experiments on the Division's spatting lease in Port Hacking, of the suitability of cemented egg case fillers for catching spat in Australian waters. Their use was recommended in the pamphlet referred to above.

(iii) *Fundamental Studies.*—(*a*) Regular sampling of commercial stock was continued during the year, but whereas small samples were taken weekly during 1940, it was decided that large monthly samples should be taken during 1941. These samples are submitted to metrological and biological analysis. Growth rate, the mode of shell formation, sexual rhythm, and certain aspects of the nutrition of the oyster are thereby studied. Indices are emerging for—(i) the role of various biological factors in relation to certain physiological and pathological effects, and (ii) the provision of commercial standards. Degree of sexual development actually determines "condition".

(*b*) Preliminary experiments with kymographic apparatus revealed idiosyncratic characteristics in type of shell movement, in the amount of time spent with gaping shell, and in the reactions to temperature change. A typical response to limital values of temperature was obtained. The apparatus has been further developed to become a type of nutrition-chamber in which, at controlled temperatures, it is possible to control salinity, dissolved gases, pH, and food, and simultaneously to observe the response in shell movement.

(*c*) The dried meats obtained in the course of regular sampling were analysed, at the suggestion of the Council, by a Sydney University research worker, financed from the Commonwealth Universities Research Grant. The aim is to show the seasonal fluctuation in the proximate constituents in order to provide a biochemical basis for the reactions of oysters to variations of environment. A curve—apparently generally characteristic—has been found for the seasonal change in glycogen content. Certain characteristics of the relationship between proximate constituents have also been shown. This work has been submitted for publication.

A study has also been made of the distribution of calcium in the waters of oyster areas on the eastern coast of Australia. It has been found that there is no variation in the calcium content of these waters such as could directly afford an explanation of the variation in shell characteristics.

(iv) *Winter Mortality.*—The experimental lease at George's River, New South Wales, has been stocked with oysters from three different localities of the New South Wales coast. The stock has been set out on a replicated block experiment in respect of origin, of oyster level in relation to mean tide level, and density of oysters on trays. A definitely lower winter mortality rate occurred at the high level than at low levels. Mortality rate was, however, shown to increase with tray density, though no clear difference existed on account of origin of oyster. During the current winter, the oysters are being examined at least twice a week and the dead oysters are being removed; hydrological observations are also being made concurrently. This procedure should give an indication of the incidence of the mortality. Correlations may also be possible between hydrological factors and mortality. The removed dead oysters are being submitted to pathological examination. Although a considerable fauna is invariably present on such oysters, part at least is saprophytic.

(v) *Co-operation.*—Because of the importance of the oyster industry to that State, the New South Wales State Fisheries Department has provided funds for the appointment of an additional officer to this Division. This officer will work initially on the problem of winter mortality and subsequently on the problems of productivity in oyster-growing waters.

9. *Hydrological Investigations.*—(i) *Oceanic.*—The number of hydrological cruises attempted in the period covered by this report was of necessity reduced to two, each occupying some thirty days. In the area traversed per cruise about 60 stations were occupied.

The results, which are now being worked up for publication, reveal some features that will be of special interest to the eastern Australian fisheries. Amongst these the most striking is the presence of several well-developed eddy systems, which seem to persist for several months and work up and down the coast. The size and actual development of these eddies have not yet been ascertained, but the extension of the outer stations on a cruise to about 50 miles should ultimately yield some of the required information. Eddy systems like these would be capable of lateral movement about a mean path of motion, and the effect of such an eddy system, moving in towards the shallower waters of the coast, would be catastrophic for the planktonic life of the region. This would have the effect of driving the local fish, which feed on the plankton, to other parts of the coast.

(ii) *Estuarine.*—The work on estuarine hydrology in connexion with the oyster investigations, salmon movements, &c., has been continued. A combined meteorological and continuous tide recording apparatus has been set up at Port Hacking in connexion with this work, and also for the study of the variation of sea level over a period of years in connexion with the oceanic investigation. A similar apparatus is being installed over the experimental oyster lease at George's River, New South Wales.

(iii) *Oyster Physiology.*—A certain amount of information has been collected about the normal requirements of oxygen by oysters, and it is hoped that these data and similar information can be used in conjunction with the ascertained variations in the oyxgen of estuarine waters to postulate the best environmental conditions for the growth, &c., of Australian oysters.

10. *Other Investigations.*—(i) *Black Bream.*—Data have been collected incidentally in the course of field work on other species. These data have permitted the publication of a preliminary note as to the spawning habits and length at first maturity of this species.

(ii) *Schnapper.*—A worker at the University of Sydney has undertaken general biological studies of this species in collaboration with this Division and with the co-operation of the New South Wales State Fisheries Department.

X. NATIONAL STANDARDS LABORATORY.

1. *General.*—Early in the year, possession was taken of the new National Standards Laboratory building, and equipment that had been received was installed. The remainder of the staff returned from the National Physical Laboratory in Great Britain, after visiting, amongst other institutions, the Bureau of Standards at Washington and the National Research Council at Ottawa. The library has been equipped, and the listing and cataloguing of books, periodicals, pamphlets, and catalogues is proceeding.

2. *Metrology.*—The activities of the Metrology Section have been directed largely to defence work and includes such items as the examination of new gauges, tools and fixtures before acceptance. Advice is also given to industry generally on the design of gauges and measuring equipment and the application of gauges.

All the main testing laboratories in New South Wales and Queensland have been visited and their testing machines calibrated. In addition, testing machines situated in many works have been calibrated on behalf of the Inspection Branches of the three Services, to whom recommendations are made concerning the approval of works laboratories.

3. *Electrotechnology.*—In order to carry out its normal functions, the Electrotechnology Section first had to establish the standard of electrical resistance. This work is normally the function of the Physics Section, but, during the absence abroad of the officers of that Section, the necessary equipment was set up, and an inter-comparison made between three one-ohm coils constructed at the National Physical Laboratory, which are to serve as the Laboratory's standard of resistance. The inter-comparison proved to be satisfactory, and the results agreed entirely with those obtained in England some months earlier. While this inter-comparison was being carried out, the opportunity was taken to test 24 one-ohm standards for authorities in various parts of Australia.

Apart from this early work, almost the whole of the resources of the Section have been devoted to confidential investigations on behalf of the Services. It has been found possible to carry out, in addition, a number of miscellaneous tests on equipment that was required for urgent war work, but, otherwise, very little progress has been made in regard either to standards or to electrical measurements.

4. *Physics.*—Substantial progress has been made in the establishment of the Physics Section following the return from abroad of the senior and another officer at the end of last year, and of a third officer a few months later.

The greater part of the equipment ordered while these officers were in England has now arrived and is being installed. While abroad, the officers made inquiries on behalf of various authorities into some matters not directly concerned with the establishment of the laboratory but arising from the war. These included the manufacture and source of supply of jewel bearings, the manufacture of optical glass, and the application of radiological methods in the testing of aeroplane castings.

It will be one of the functions of the Section to maintain the International Temperature Scale, and much of the necessary fundamental equipment for this purpose and for the calibration of thermometers over a wide range of temperature is installed. A number of calibrations of base metal and rare metal thermocouples have been made for firms and institutions occupied with defence work. Assistance has also been given to the Prince Henry Hospital, Sydney, on temperature problems in the preparation of blood serum for storage.

The standards of resistance and voltage of the Commonwealth will be maintained by the Section. Most of the necessary equipment has been assembled and put into operation.

XI. AERONAUTICAL INVESTIGATIONS.

1. *General.*—During the year the work of the Aeronautical Laboratory was given the status of a Division, and the former Officer-in-charge has now become its Chief.

The Division has been in occupation of its laboratory buildings for a little over a year. However, certain important items of the larger types of equipment which it is necessary to obtain from abroad are still incomplete. In the last two years, the number of service aeroplanes has not only grown very rapidly, but increasing proportions of both the aircraft and of the materials for manufacturing them are being produced in Australia. The Division is accordingly assisting this work in two fields, namely, that of the manufacture of the complete aeroplane and that of the special materials from which the aeroplane is built. In the latter field, the big problem is to reduce the numerous British, American, and private specifications to a much smaller number of specifications suitable for the smaller selection of specialized materials available in Australia. The Division has helped other organizations, e.g., the Standards Association of Australia, in this work, which has now borne fruit. For example, in the field of light alloys, about 100 different specifications have been reduced to about 30 simple specifications covering six or eight basic compositions. The same has been done with steels. These materials can, with a negligible loss of efficiency, be substituted for the more specialized materials used abroad.

2. *Work of the Laboratory.*—The work of the Division is organized into four sections, the operations of which are discussed below :—

(i) *Structures and Materials Section.*—(*a*) *Investigations on Timber for Aircraft Construction.*—This investigation is being carried on in close association with the Division of Forest Products. As initiated early in 1939, it had two aims : (1) to discover species of Australian timber suitable for aircraft construction in the form of solid timber for spars, booms, &c., and as veneer for plywood ; (2) to develop a rational method of designing wood spars which would supersede the present method which utilizes empirical " form factors ".

As a result of intensive work by the Division of Forest Products, several suitable timbers of each class have been found, and the total quantities available are sufficient for the maximum probable requirement. Although further work is desirable on the basic timbers, other problems have been shown to be more urgent. In particular, the gluing of certain joints in wooden aircraft has been found to be defective in sample aircraft components sent to the laboratory for test. An investigation to develop a better technique and to examine the deterioration of joints has been started at the Division of Forest Products.

There are many uncertainties in the design of wooden aeroplanes which do not trouble the designer of a metal aeroplane, and for this reason the average designer will avoid timber construction till a shortage of metal compels its use. Design teams are being built up round steel and duralumin construction, but a rapid change to wood or composite construction may be required if a shortage of aluminium occurs. To provide design data and experience, the Division is investigating the design of box spars, tests on the first series (effect of variation in flange proportions) having been completed, and the design of two-spar stressed skin construction. Other

projected work includes the effect of plywood webs in box spars, the design of wooden wings to replace the steel wings of an obsolescent service type aeroplane, and the construction of parts using moulded wood veneer and plastics.

(*b*) *Structural Tests.*—Modern aircraft structures are so redundant and complicated that they can never be completely analysed. Since no margin of safety in the form of extra weight is permissible, it is customary to check the calculations by strength testing all important structural components. These tests are not easy, because a great many loads must be applied simultaneously to the structure, and their magnitude is large. Elaborate test rigs are often necessary. The Section has completed or has in hand tests of structural components for four new or re-designed types of plane. In addition, several requests to investigate the causes of structural failure of certain aircraft have been dealt with.

(*c*) *Materials.*—A great deal of testing is done to see that materials manufactured in Australia as substitutes for British materials comply with the relevant specifications. The laboratory is equipped to deal with most of this work. Fatigue testing has proved slow with the existing Wöhler and N.P.L. type machines running at 2,000 r.p.m. Light alloys, for example, have limits of over 100,000,000 cycles, and the advisability of installing machines running at 10,000 r.p.m. is being considered.

In addition to checking of materials for uniformity to specification, all new specifications are examined to co-ordinate them with existing ones. Assistance is also given to local manufacturers in the production of materials and aircraft components that were previously imported. Finally, failures in the finished parts or defective materials are examined and reports prepared ; a large part of the metallurgical equipment has now been installed and further work in this field will be now possible.

(ii) *Aerodynamics Section.*—The basic equipment of the Aerodynamics Section is the wind tunnel in which a wide range of aerodynamic tests may be made. The large steel duct through which the air flows has just been completed and installed in the building provided, and the 550 h.p. driving motor and the motor generator set forming part of the Ward Leonard control arrived from England in June. This motor will be mounted in the tunnel in the centre of a large steel section forming part of the duct.

A large amount of equipment required for operating the tunnel has now been obtained and is being installed. The largest item is the Ward Leonard controlled frequency changer unit, which is required to drive small motors fitted into the wind tunnel models to rotate the airscrews. With this equipment, the engine-on conditions pertaining to an aeroplane in flight can be accurately represented on the model (e.g., take-off, climb, top speed, and landing conditions) and controlled entirely from outside the tunnel. Two small motors for fitting into the model have been obtained. The unusual feature of these model motors is their ability to develop a large horse-power inside a small diameter (outside diameter $3\frac{1}{4}$ inches, length 5 inches, 5 h.p. at 18,000 r.p.m.). A balance manometer has been designed and constructed for the accurate measurement of the wind tunnel speed. This instrument is fitted with an electrical device for indicating the balance point at which a desired wind speed is obtained. This type of manometer allows the remote indication of wind speed at any point in the wind tunnel building and may therefore be used to co-ordinate tests in which three or four observers are required at different points around the tunnel. The manometer can also be used to control the wind speed in the tunnel. Other items of operational equipment are (1) a precision manometer used to calibrate all other manometers ; (2) telescopic protractor to be mounted on the working section of the tunnel for measuring the angular attitude of the model under test ; and (3) pitotstatic tubes and yawmeters for the exploration of velocity distribution in the tunnel. The large three-component balance for measuring the lift, drag, and pitching moment on the model is nearing completion at the makers' works in Australia. The special foundations and levelling devices required for this balance are ready, and calibrating frames and pulleys required for its calibration are under construction.

(*a*) *Wind Tunnel Tests.*—The lack of a tunnel has been a great handicap in helping the aircraft industry. This has been overcome to some extent by using the low-speed wind tunnel belonging to the School of Engineering at the University of Melbourne which was placed at the disposal of the Division through the kindness of Professor Burstall.

(*b*) *Design of Fans and Ducts.*—The design of airscrew type fans has occupied much of the attention of the staff. These fans have a very high efficiency, and are being used in increasing numbers for both research and industrial purposes. The labour in computing fans of this type is very great by normal methods, and the data are scattered through many journals, text-books, and unpublished reports. The aerodynamic staff has collated this information and has developed, improved, and simplified methods of calculation. This work has already proved its value, as five fans for widely different purposes have been designed. They varied from 3 h.p. to 550 h.p. and from four to twelve blades.

The Section has also made a special study of duct design, since in the design a fan cannot be divorced from its duct system. This knowledge was used in the design of the wind tunnel, and to aid the University of Sydney in the design of its new tunnel.

(*c*) *Flight Testing.*—Performance testing in flight forms part of the duties of the Aerodynamics Section. Though a special flight at Laverton is still awaiting official sanction, preparatory work has been done. A standard type test schedule has been prepared, setting out in detail the tests for performance, stability, and service suitability. The preparation of special flight instruments and the selection of a speed course is in hand.

(*d*) *Mathematical Work.*—The Section has spent a good deal of time on the mathematical analysis of certain problems, other than the work on fan design, already mentioned. For instance, it is necessary to correct the results of tests made in a wind tunnel for the presence of the walls. These corrections have previously been calculated for rectangular and circular tunnels, but not for the irregular octagonal shape of the Council's tunnel. This calculation has, therefore, been completed, the method employed being novel. Also the drag of a wing or aerofoil increases very rapidly when the speed approaches the speed of sound in air. Due to the shape of the aerofoil, the local velocity at parts of the surface is much higher than the general speed of flight, and local breakdown occurs. The aerofoil shape to give the least local increase of velocity has been mathematically determined. In addition, a jet propulsion scheme put forward by a serving officer and based on mathematical premises has been analysed and reported on and the mathematical calculations made to determine a particular aspect of the defensive armament of a new type of aeroplane.

(iii) *Engines and Fuels Section.*—The work of the Engines and Fuels Section has been handicapped by difficulty in obtaining engine testing equipment. To date only one test set, of the four ordered, has been obtained, but a DPX 3 dynamometer has also been obtained through the courtesy of the University of Tasmania.

(*a*) *Engine Testing.*—Since, in spite of lack of equipment, test work had to be done, two 225 horse-power dynamometers were borrowed from the University of Melbourne and the Melbourne Technical College, and test sets were built up. Two of these improvised test sets were for air-cooled engines, and cooling fans designed by the Aerodynamics Section were incorporated.

An Australian-built Gipsy-Major engine was subjected to the full Air Ministry type tests for civil aero engines, and a high power automobile engine was tested to determine whether its performance was up to requirements. A temporary single cylinder plant incorporating a Wasp engine has been constructed and is now ready for work on certain special problems.

Rotary valves, as compared with conventional poppet valves, have been shown to give increased power and reduced fuel consumption for engines, but, so far, mechanical difficulties have limited their practical application. A locally invented valve shows promise of overcoming these mechanical limitations, and is considered worthy of development for an aero or a tank engine. As a preliminary to this development, a 12 horse-power, six-cylinder automobile engine incorporating the rotary valve was calibrated against a dynamometer for power and fuel consumption, carburation and mixture distribution being studied during the tests. Tests of a small single cylinder unit were also made to obtain optimum valve overlap, timing, &c. On the basis of the results, a four-cylinder aero engine has been re-designed to incorporate the rotary valve, and the parts are now being manufactured. It is intended that the work shall continue, the next step being the building of a large single cylinder unit so designed that all variables likely to affect performance can be studied.

(*b*) *Testing of Ignition Equipment.*—The manufacture of ignition equipment is under way in Australia. In view of these developments, it was thought desirable to assemble apparatus to test such equipment, and, more important still, to decide on a specification of tests, as the British and American requirements differ in many respects.

(*c*) *Engines and Fuel Systems.*—The C.F.R. fuel testing engine was delivered in 1940. The technique of octane rating fuels is not simple, and the Division was fortunate in that the Shell Co. of Australia Ltd. made available the whole time services of an engineer from its staff. He has initiated the procedure, and the laboratory now regularly participates in the routine testing of sample fuels, whereby correlation between the C.F.R. engines at various establishments is maintained. From time to time fuels have been sent for test by the various air operating companies. Various items of fuel testing equipment have been assembled, e.g., a bomb calorimeter, distillation fraction apparatus, and vapour pressure apparatus. Various components required for fuel and oil systems, such as hand and engine operated fuel pumps, flowmeters, flexible petrol and oil pipes, and oil coolers, have also been tested on request.

(iv) *Instruments Section.*—Although the development of the work on instruments has been curtailed due to lack of personnel, a fairly complete range of aircraft-calibrating equipment has been installed, and this has been used to calibrate sub-standard equipment made in Australia.

For example, calibrating manometers for airspeed indicators have been calibrated against a master airspeed indicator calibrator. Similarly, two barometers graduated for calibrating altimeters were calibrated against a standard instrument.

Special apparatus which cannot be obtained from trade sources is often required for research. It is necessary to develop and build such items in the Division, and an instrument workshop has been equipped for the purpose. This workshop has made, for example, a number of resistance strain gauges which are composed essentially of fine resistance wires bonded in thin strips of bakelite and then cemented to various parts of the structure. Strain causes a change of resistance which is recorded electrically. An audiometer for noise measurements in cabins and which is simpler and lighter than existing designs has been constructed, and an electromagnetic autographic stress strain recorder is being developed.

XII. INVESTIGATIONS IN INDUSTRIAL CHEMISTRY.

1. *General.*—Following the formation of the Division of Industrial Chemistry, it was necessary to concentrate firstly, on the design and erection of a laboratory, secondly, on obtaining essential general equipment from abroad, thirdly, on recruitment of staff, and, fourthly, on design and fabrication of equipment for special purposes.

Tenders for the construction of the laboratory buildings were let in October, 1940. In their construction, special attention has been given to the design and installation of services and drainage. Adopting the principle that the research officers should not spend time in improvising services that can be conveniently provided, hot and cold water, steam, town gas, compressed air, and vacuum will be made available in all individual laboratories. A conveniently tapped three-phase, a.c., electrical installation will serve all laboratories and d.c. current will be available where required. In some rooms for bacteriological work, filtered air is to be circulated. It is now expected that the main laboratories will be ready in August; certain sections of the chemical engineering block are already in use.

Considerable economies have been made possible by sharing a site with the Division of Aeronautics, and the artisan staff has been installed in the workshops for several months. This has been particularly helpful under present conditions and much material that would normally have been bought is being fabricated in order to save time and money.

Since September, 1940, recruitment of staff has proceeded steadily, and many of those appointed have been greatly assisted by being accommodated in the laboratories of outside organizations, in particular the University of Melbourne. Senior officers were appointed some little time before they commenced laboratory work, in order that they should have adequate opportunity to plan their researches, to study relevant literature, and to make contacts with industry.

2. *Co-operation with Other Bodies.*—Wholehearted co-operation with industry has been sought, because it is realized that maximum benefits can come from the Division's work only if its scientific officers are able to draw on the experience of those with detailed technical knowledge of the industries to be served. Various trade associations have welcomed the creation of the Division, and cordial relations have already been established with them.

Since investigations have been started in some fields, it has sometimes become necessary to point out that a new Division should not at first spread its activities too widely, and that consideration of the problems of a number of industries must for the present, be deferred. In general, this explanation has been sympathetically received, but it is apparent that the Division will have to expand rapidly if it is to serve the many industries seeking its assistance.

The Division is co-operating with other Divisions of the Council, with Universities, and with various Commonwealth and State Departments. Such co-operation relates to such matters as the control of chemicals, the stimulation of the use of producer gas, the drying and concentration of foodstuffs prior to shipment overseas, effluents, and wool investigations.

3. *Research Projects.*—Work has commenced in most of the fields enumerated in the last report. An endeavour has been made to select problems that have a bearing on the conduct of the war or on national defence, but post-war problems have not been disregarded. Since the security of the British Commonwealth is becoming more dependent upon the industrial productive capacity of its constituent members, a broad interpretation has been placed upon what is meant by work that will assist in defence. Thus it is considered that every expansion of established industry in Australia, and every new industry established, increases capacity to withstand aggression.

(i) *Dairy Products.*—In conjunction with the Section of Dairy Research, the Division has commenced its investigations on chemical engineering aspects of the dairy products industry. Production of butter and of cheese tends to follow the traditional methods that have been passed down from prehistoric times. Half the food value of milk is wasted in the manufacture of butter,

and one-third in the manufacture of cheese. Little effort is made, as a rule, to use for human consumption the skim milk, the buttermilk, or the whey. Insufficient attempts have been made to apply certain chemical engineering principles developed in other phases of industry to butter and cheese production, or the drying of milk, whether skim or full-cream; long-term investigations have accordingly been planned to help the industry overcome some of these faults. The efforts of the investigators at the present time, however, are directed to shorter-term projects such as the production of concentrated foodstuffs and foodstuffs that do not require refrigeration. In particular, England's needs with regard to dried milk, cheese, and butter in a form that will keep without refrigeration are continually borne in mind. An attempt is being made to produce dried cheese for the fighting forces.

There are two main economic reasons behind this work. Firstly, shipping difficulties necessitate the selection of foodstuffs in concentrated form, and in a form that can be shipped without refrigeration ; it is clear, therefore, that if Australia is to retain its markets, its products must conform to these requirements. Secondly, because of the rapid expansion in the use of margarine, an expansion which long ante-dated the outbreak of the present war, Australia in years to come may not be able to sell as much butter as formerly, and research on the production of other dairy products thus becomes advisable. There is a third, even more potent, reason for change, namely, that England needs concentrated foodstuffs, and, apart from economic considerations, this country has a duty to see that she receives them.

(ii) *Wool.*—(*a*) *"Unshrinkable" Wool.*—The woollen industry has indicated that one of its major interests is the production of " unshrinkable " wool. Of the several rival processes for the production of shrink-proofed wool, one, namely, the Freney-Lipson, is being developed by the Council. Work on this process, which originated in the Council's McMaster Animal Health Laboratory, was transferred to the Division of Industrial Chemistry just prior to the beginning of the period under review. In the laboratory, optimum values of the variables have been determined and the permissible limits of variation ascertained. Quantitative tests on treated materials (mostly socks) have indicated that treatment leads to a longer wearing life of the garments.

Large scale tests of the treatment have been carried out in collaboration with commerical interests in Melbourne and Sydney, in the former for piece-goods (socks) and in the latter for tops. Though these tests have been encouraging, some few manipulative difficulties must be overcome before the process can be recommended for widespread technical adoption, assuming that manufacturers are satisfied concerning costs. Some thousands of pounds of wool have been treated during these tests. Improved methods for continuous treatment of tops and for batch treatment of piece-goods are at present receiving attention. The tests are being carried on as speedily as possible so that an authoritative statement can be made in the near future.

Arrangements have been made with the Wool Industries Research Association of Great Britain by which a plant for the Woolindras shrink-proofing treatment will be erected at Fishermen's Bend. The plant, which arrived late in June, 1941, will be used for demonstration purposes and also to enable the Council's investigators to become conversant with the process developed by a sister institution in England. In Great Britain, shrink-proofed materials only are accepted for the Services.

Studies have been continued on the theory of the felting of wool, on which shrinkage depends, and on the manner in which shrink-proofing agents alter the wool fibre. The associated physical properties of wool, upon which the handle or degree of smoothness depends, are also receiving attention. Wool, being of such importance to Australia, the more there is known about it the better, and fundamental investigations of its physical and chemical properties are most desirable, even in war-time. The Council's own shrink-proofing process originated from such studies, which may be expected to help wool withstand competition from substitute materials in the post-war period.

(*b*) *Wool Wax.*—Another project of interest to the woollen industry has been commenced by the recently formed Organic Section. In Australia's wool clip there is annually 100,000,000 lb. of wool wax, for the greater part of which, up to the present time, no adequate market has been found. Experimental work has been commenced with the objects of ascertaining more accurately than hitherto the nature and percentage of the constituent organic acids and alcohols, of devising methods for their isolation, and of finding uses for them. At the present time some few Australian mills recover wool wax which, after refining, is sold as lanoline. The market for this material, however, is not such as to encourage the installation of recovery plant at all mills.

(iii) *Fellmongery.*—The fellmongering industry is based on tradition rather than scientific control. Formerly, France treated 70 per cent. of Australia's sheepskins, and the local fellmongeries are now attempting to put through much larger numbers of skins than normally. In northern Australia, the fellmongeries use what is known as the sweating process to bring the skins into such a condition that the pelt and the wool are easily separated from one another.

In Victoria, painting with a depilatory effects the same purpose. The sweating process is apt to harm the pelt, the painting process the wool, and the choice of process is governed largely by the relative value of pelt and wool, that is, whether the skin comes from crossbred or merino. The sweating process depends upon the action of bacteria in warm sweathouses. In winter-time, four days may pass before the skins are ripe for pulling, whereas in hot, humid weather, 36 hours may suffice, and the pelt is lost if the wool is not pulled immediately. Variation from day to day in the ripening period leads to heavy over-time expenses, loss of skins is high, and the manual labour is sometimes so objectionable that the workmen prefer almost any other work. It is hoped that the research work now well in progress will demonstrate that much of the uncertainty, the loss of material, and the unpleasantness may be eliminated, and that fellmongery need not continue to be the Cinderella of Australia's industries.

(iv) *Minerals Utilization.*—In the mineral field so many worthwhile research projects have come to notice that the choice of problems for immediate research has not been easy. The first work has been on problems for which laboratory accommodation and equipment could be found ; consequently, it has been necessary to postpone research work in such desirable fields as cement, ceramics, refractories, and in the benefication of certain minerals at present imported, until better facilities and increased staff are available.

The major investigation already under way is concerned with the exploitation of certain beach sands of the northern coast of New South Wales. In these sands, Australia possesses an asset that is unique ; here Nature has provided at least 1,000,000 tons of what may fairly be described as a mixed concentrate of zirconium and titanium minerals with a smaller amount of monazite sand. No better deposit of zirconium mineral is known. One company has shipped this material, scooped from the beaches, to the Niagara Falls area for processing. An Australian company, however, has succeeded in separating it into a zircon concentrate, a mixed rutile-ilmenite concentrate, and a low-grade monazite concentrate, the greater proportion of which concentrates are shipped overseas for processing.

From the zircon concentrate can be produced excellent refractory bricks, glazes for the ceramic industry—particularly for electrical insulators—and a variety of zirconium alloys which will be receiving attention in the future. From the mixed rutile-ilmenite concentrate research work is required to produce the two constituent titanium minerals in pure form, and to develop local uses for them. Already titanium compounds are widely used as fluxes in welding, as constituents of smoke screens and of paints, and for the manufacture of cutting tools (titanium carbide). Large quantities of titanium white, now on the list of prohibited imports, were formerly imported for the manufacture of white paints. Production from an Australian source is evidently worth investigation.

The monazite concentrate could well be utilized in the manufacture of a number of valuable products, from pyrophoric alloys to embalming compounds, from tracer bullets to searchlight carbons, from ceramic glazes to triplex glass.

The Division is playing a part in the attempt to overcome Australia's potash shortage. It has two officers in Western Australia helping the State and university authorities to develop a process for utilization of the extensive alunite deposits of certain lake beds of that State, from which it seems there is a reasonable prospect of obtaining potassium sulphate on a commercial basis. These two officers will also help in the attempted production of purified alumina for the manufacture of aluminium metal.

An attempt is being made to ascertain whether pyrolusite of local origin can be substituted for the imported material used in the manufacture of dry cells. This may involve a search for a suitable method of beneficiation of Australian ores. Such a method might well rescue the mining of manganese ores from its present unfortunate position. The major buyers insist on a certain minimum grade and put certain impurities on a penalty basis ; this results in hand-picking of ore and dumping of much ore of inferior grade. Successful beneficiation would presumably remove this weakness from our steel economy. Continuation of the present wasteful methods of exploitation would lead inevitable to depletion of high-grade ores and thus to still greater dependence on imported ores.

(v) *Producer-gas Investigations.*—Those officers of the Division who have been employed during the past year on producer-gas investigations have confined their attention to a study of the suitability of Australian hardwoods for the production of charcoal. Methods for the estimation of important physical and chemical characteristics of charcoal have been standardized, and values determined for charcoals from various hardwoods. Methods of analysis of the producer gas itself, and methods of determining of tar content, calorific value, &c., have been investigated and standardized. The Division also superintended the burning and distribution of several tons of standard charcoal for use in type tests of producer units. The work of the Division's investigators has been the basis for drawing up Australian specifications for charcoal for use in producer-gas vehicles. Their results were published first as a confidential document by the

Standards Association of Australia, and subsequently as the Council's Pamphlet No. 103. The work involved was carried out in the Department of Engineering at the University of Melbourne, in co-operation with Professor A. Burstall.

(vi) *Foundry Sands.*—Mr. A. A. Robertson, while head of the Metallurgy Department, Melbourne Technical College, arranged for the accommodation of the Council's foundry sands investigations in his department. The college authorities generously continue to provide accommodation for the work. An advisory committee was set up to plan the general trend of the investigations, with a technical sub-committee to take charge of the detailed direction of the work. When the Division of Industrial Chemistry was formed the investigations were placed under the administrative control of the Chief of the Division.

It was felt that, at first, the work should be mainly of an exploratory nature, and that every attempt should be made to establish contact with the industry and to outline its problems. Accordingly, the investigator has visited a number of foundries and sand-pits, has given several lectures, and has maintained close contact with the Institute of Australian Foundrymen.

An extensive bibliography has been prepared, much scattered information having been collected in a form more readily useful alike in connexion with the investigational work and in answering inquiries from foundrymen. A complete set of testing equipment has been gathered together for use in the work, and investigations are in progress on the following projects : survey of moulding sand practice in Australian foundries, binding materials for synthetic moulding sands, and variation in sands supplied to Victorian steel foundries. Much preliminary work has been necessary before a commencement could be made on the main projects. A series of reports concerning the work done will be issued shortly.

XIII. OTHER INVESTIGATIONS.

1. *Lubricants and Bearings.*—(i) *General.*—Substantial progress has been made during the past year in the building up of a research organization and the development of research methods for dealing with the lubrication, bearing, and wear problems in Australia. The work is undertaken as a co-operative research with the University of Melbourne and is housed in the new Chemistry School.

During the past year, the work of the Section has fallen into two parts. The first is the design and construction of the necessary apparatus and equipment of the laboratories. The second is the attack on the various problems that the war has made urgent in this country. The attack on bearing, wear, and lubrication problems is necessarily an experimental one, and complex apparatus and equipment is required. The major part of this apparatus has been constructed and installed and is now in use. With a few minor exceptions, all the apparatus was designed by members of the Section and has been locally made. A considerable part of it was made in the workshops of the Engineering School. The Department of Natural Philosophy is helping with certain physical aspects of the work and the Department of Metallurgy is co-operating on some of the metallurgical work.

The Section is working in collaboration with the various interests and organizations concerned on the development and production of aircraft bearings and on lubrication and other problems. It is also collaborating with other industrial organizations on lubrication, wear, and allied problems, and is assisting as far as possible in the development of local products.

(ii) *Bearings.*—The older form of white-metal bearings is unable to stand up to the severe conditions of load, speed, and surface temperature which occur in the major bearings of the modern high-speed aero engine. This has necessitated the development of special bearing metals which will have the correct mechanical, physical, and frictional properties. The problem is a highly technical one, and very small variations in the composition or structure may have a profound effect on the performance.

(*a*) *The Frictional and Seizure Properties of Bearing Metal.*—A special apparatus has been constructed for investigating the frictional and seizure properties of bearing metals. This apparatus measures simultaneously the coefficient of friction, the rate of wear, the area of contact, and the surface temperature of the sliding metals, and is so designed that any desired load or speed can be reproduced. The rapidly changing phenomena are analysed by means of cathode ray oscillographs, and the combined measurements give a fairly complete and detailed picture of the physical processes that occur during sliding and seizure. The results obtained provide a valuable guide in the selection or rejection of bearing alloys, and are also of theoretical interest, since they throw light on the general mechanism of friction and the causes of wear.

The same apparatus is being used for studying the wear and frictional properties of steel, cast iron, and other metals. It is also used for investigating lubricants.

(*b*) *The Mechanical Strength of Bearing Metals and Elevated Temperatures.*—Although some information is available as to the mechanical properties of bearing metals at room temperature, comparatively few measurements have been made at higher temperatures. Recent work has shown that the local surface temperature of a running bearing may be high, although the mass of the metal appears to be cool. It is clearly important to study the mechanical properties at the temperatures that occur in service. Apparatus has been constructed for measuring the mechanical properties of bearing metals over a wide temperature range, and work is in progress on a number of alloys.

(*c*) *The Manufacture of Bearings.*—The correct manufacture of bearings, after the alloy has been selected, is also of great importance. Quite small defects may lead to the failure of the bearing, and unless the technique of casting is carefully worked out and controlled, these defects readily occur. A laboratory has been equipped for the manufacture of experimental bearings. This contains apparatus for stationary and for rotating casting and for the electrodeposition of metals. It is so designed that the temperatures, atmosphere, speed of casting, &c., can be accurately controlled and reproduced. New techniques for the manufacture of some of the more important aircraft bearings have been worked out and the bearings made. These bearings, which were the first of their kind to be made in Australia, passed the practical tests satisfactorily and are now in use. The details have been communicated to manufacturers, who are now successfully producing these bearings in quantity.

(*d*) *The X-ray and Micro-examination of Bearings and the Testing of Bond Strength.*—The more obvious defects in bearings which must be guarded against are (1) porosity in the metal or at the bond, (2) faulty adhesion to the steel shell, (3) metal segregation in the alloy and incorrect crystal size and structure.

Since these defects occur beneath the surface they cannot be revealed by ordinary inspection. They may, however, be revealed by X-rays, by an examination of the micro-structure, and by mechanical tests. A combined investigation by these methods has been made of a large number of bearings of different types, both imported and locally made.

(*e*) *Bearing Testing Machine.*—A bearing testing machine which reproduces on the bearing some of the more severe conditions which occur in the aircraft engine is being constructed. This machine will enable testing and preliminary selection to be done in the laboratory.

(iii) *Lubricants.*—The laboratories have been equipped and special apparatus constructed for the physical and chemical investigation of lubricants and lubricating oils, and a number of investigations are in progress.

(*a*) *The Analysis of Friction.*—Recent experiments have shown that, under certain conditions, the sliding of metals may not be a continuous process but may proceed intermittently. Certain lubricants are, however, capable of causing continuous sliding, and the results show that such sliding is accompanied by a decrease in the wear and seizure of the surfaces. An apparatus has been made for measuring and analysing the friction and for studying the boundary lubrication properties of oils and lubricants. It has been used for investigating the lubricating efficiency of a number of lubricating oils and greases in order to determine their suitability for various special purposes.

(*b*) *The Influence of Temperature on Lubricants.*—In general, the lubricating efficiency of an oil decreases as the temperature is raised, and experiments have shown that this is due to the desorption, from the surface, of polar constituents initially present in the oil. An oil that is a good boundary lubricant at room temperature may cease to be effective when the metal surface is warmed, and the transition may occur at temperatures well below 100° C. Since temperatures of this order readily occur in practice, e.g., in a running engine or bearing, the observation is of practical importance. A study of the effect of temperature on the lubricating property of oils and of greases has been made so that those suitable for lubricating hot surfaces could be selected.

(*c*) *Chemical Analysis of Oils and Standard Air Ministry Tests.*—A small laboratory has been equipped with modern apparatus for the chemical analysis of oils, for the measurement of viscosities, and for carrying out the standard Air Ministry oxidation and other tests. A considerable number of oils of various types have been analysed. In particular, an investigation has been made of the amount of contamination that occurs with the lubricating oil used in producer-gas vehicles, and work has been done on the reclamation of used lubricating oils.

(*d*) *The Lubrication and Wear of Piston Rings and Cylinders.*—A single-cylinder engine which is suitable for investigating a range of lubrication and wear problems has been designed and constructed. It is so designed that the lubrication systems of different parts of the engine are isolated from one another. The engine can be run under accurately controlled conditions, and the temperature of the various parts can be measured. It is coupled with a generator and dynamometer so that the frictional losses can be determined.

Progress has been made in studying the mechanism of lubrication between the piston ring and the cylinder wall of a running engine, and in determining the conditions under which this changes from fluid to boundary lubrication. The results have an interesting bearing on the problems of piston ring and cylinder wear.

(iv) *Friction and Wear.*—(*a*) *Polishing and Grinding of Flat Surfaces.*—The various investigations on friction lubrication and wear necessitate the use of large metal and other surfaces that are flat, and that have a standard surface finish. A grinding apparatus has been made and a small laboratory equipped for automatic grinding and polishing, so that optically flat surfaces with any required degree of surface finish can be rapidly produced.

(*b*) *The Wear of Producer-gas Engines.*—There has been some doubt as to the amount of engine wear that occurs in Australian vehicles operating on producer gas. A series of measurements was therefore begun on commercial vehicles. Authorities in the different States are collaborating, and the cylinder and piston ring wear is measured after the vehicle has completed 10,000 miles. The sump oil from these vehicles is also withdrawn every 1,000 miles and analysed, so that the amount of contamination and deterioration of the lubricating oil can be determined. So far, the measurements have been completed on ten vehicles. The results have been communicated to the Producer Gas Technical Committees and to the Department of Supply and serve as a guide in fixing the standard specifications of the maximum amount of dust that is allowed in the gas stream. Other experiments on the effect of the nature, size, and concentration of the dust particles on wear of lubricated surfaces are in hand.

(*c*) *Cutting Fluids.*—Work is being carried out in collaboration with local manufacturers on the development of high-grade cutting fluids which may be used in place of the imported products. A series of tests on the cutting efficiency of different fluids has been completed, and further work on the extreme pressure properties of the locally made fluids is in progress.

(*d*) *The Impact of Colliding Surfaces.*—Experimental work on the nature of contact between colliding surfaces is being continued on measurements made of the time of impact, the area of contact, and the momentary surface temperature developed during collision. The measurements are made in the presence, and in the absence, of lubricating films, and the results have a bearing on lubrication, wear, and other problems.

(*e*) *The Theory of Metallic Friction and the Lubricating Effect of Thin Metallic Films.*—An investigation has been made into the mechanism of friction between a hard metal sliding on a softer one and in particular of the friction of steel on indium which is a soft metal. The theory suggests that the total frictional resistance is made up of two parts : one part represents the force required to plough out the softer metal, the other the force required to shear the metallic junctions formed at the points of contact between the surfaces. The experiments support the theory, and show that the friction may be calculated in terms of the known physical properties of the metals. The friction of clean steel on pure indium is high, but if the indium is present as a thin film the friction may be very low indeed and may be less than that of lubricated metals. Apart from their theoretical interest the results have important practical applications to the manufacture of bearings and bearing alloys.

(v) *Miscellaneous.*—A number of shorter investigations have been carried out to assist various industrial firms with practical problems. These range from the corrosion of oil pipe lines to the lubrication of ice cream machines. Members of the Section are assisting various Technical Committees and in connexion with a course of University lectures on friction and lubrication.

2. *Dairy Research.*—(i) *General.*—The work of the Dairy Research Section has been centred at the School of Dairy Technology, Werribee, where facilities were generously made available by the Victorian Department of Agriculture, and several investigations were conducted in close collaboration with officers of the Department.

(ii) *Survey of the Properties of Australian Butter.*—Australian butter is produced under a wide variety of conditions of climate, soil type, and pastures. The Australian Committee on Animal Production considered it advisable that information should be obtained on the influence of these conditions on the properties of butter. The State authorities agreed to collaborate in obtaining the desired information. Districts with characteristic conditions of production have been selected in each State, and monthly samples of butter are obtained from these districts by the State Departments of Agriculture, together with records of the conditions of production of the cream and details of the method of butter manufacture. Analytical data on the butter and butter-fat are obtained, and the results are forwarded to this Section for co-ordination. Records for the full 1940–41 season's production are now available for several States. Unfortunately, this season was unusually dry in most parts of Australia and the results obtained, although interesting, may not be typical. The highest and lowest values observed for the fat constants were as follows :—melting point 35.2–30.5, iodine value 42.9–29.5, Reichert value 33.2–24.2, saponification value 235.3–221, colour of butter (Lovibond yellow units) 7.1–2.0, colour of fat

(2 grams to 10 milligrams with chloroform in 1 centimetre cell) 11.0–0.8. The great variations in the colours are particularly notable. The conditions under which the fat having the lowest colour was produced were reported thus: "Through drought conditions pastures are extinct, supplementary feeding is hay chaff, crushed oats, and bran when procurable; tainting weeds, nil". Naturally, the quantity of butter made under such conditions is very small and not representative of Australian butter as a whole.

(iii) *The "Rabbito" Defect of Butter.*—This butter defect has in the past been responsible for serious losses. It gives rise to a most objectionable odour on the surface of the butter a few days after manufacture. With the recognition of its bacterial origin, the incidence of the taint has lessened somewhat, but it is still a factor in quality, particularly in the case of printed or blended butters. Persistence of the defect and its continued importance under the name of "surface taint" in Canada and the United States of America have prompted further investigation. There has been some suggestion in the results obtained that excessive heat treatment of the cream favours the occurrence of the defect. This point is being investigated. A review of the literature dealing with "rabbito" and "surface" taints in butter has been published.

(iv) *The Flavour of Sweet Cream Butter.*—Sweet cream butter has a pleasant mild flavour, which is, however, sometimes considered to be rather insipid when compared with that of a sour cream butter. Several methods have been proposed for increasing the flavour of butter from factories that receive sweet cream. A common practice is to allow the cream to sour and then neutralize and pasteurize before churning. Another method is to pasteurize and add a small proportion of "starter" to the cold cream, which is held at a sufficiently low temperature to prevent the development of acidity in the cream. The influence of these practices on the grade of butter before and after storage has been investigated in collaboration with officers of the School of Dairy Technology and two commercial factories. It was found that under commercial conditions neither method consistently improved the quality of the butter and sometimes they appreciably reduced it. The grade was generally improved slightly by the addition of a minute amount (0.2 parts per million) of diacetyl, but this practice cannot be considered as normal to butter-making since there is doubt as to its legality. As choicest grade butter of good keeping quality can be consistently made from choicest grade cream, it appears inadvisable to go to the additional trouble and risk involved in attempting to obtain a somewhat stronger flavour.

(v) *The Curd Content of Butter.*—The proportion of curd in butter is usually about 0.8 per cent., although considerable variations from this figure occur. By modifying the methods of manufacture it is possible to increase the proportion to about 1.5 per cent., which would represent an appreciable increase in factory over-run. Work has been done in collaboration with officers of the Victorian Department of Agriculture at the School of Dairy Technology, Werribee, on the influence of various manufacturing methods on the proportion of curd incorporated in the butter, and the influence of the curd on the keeping quality of the butter. No evidence was found that when the butter was properly made the proportion of curd has any appreciable effect on butter properties.

(vi) *The Storage and Transport of Butter-fat without Refrigeration.*—The desirability of evolving methods for the storage and transport of butter-fat without refrigeration became increasingly evident during 1940. The principal cause of butter deterioration at room temperatures is bacterial action in the aqueous phase, and when held at high temperatures the butter partially melts, so destroying its structure. If bacterial action is suppressed by preservatives, oxidative changes occur which lead to deterioration.

The possibilities of suitably treated "plastic cream" having better keeping qualities than butter were investigated. "Plastic cream" is ordinary cream separated to a fat content of about 80 per cent. It was considered possible that the nature of the product would help to protect it against fat oxidation and physical changes due to melting, whilst biological activity could be suppressed with a harmless preservative such as salt or cane sugar. In general the results failed to give promise of success on a commercial scale. With 20 per cent. of salt in the aqueous phase of the cream, the growth of bacteria, yeasts and moulds was controlled, but at temperatures above 20° C. tallowy flavours due to fat oxidation became evident. The incorporation of certain anti-oxidants gave some measure of control over oxidative changes, but their use commercially would be impracticable. Below 20° C. the salted product kept fairly well, and at refrigerator temperatures it was found possible to keep the cream sweet for as long as six weeks without any preservative. From the viewpoint of its effect on keeping quality, salt was found to be superior to cane sugar. In this connexion, it is interesting to note that proposals have been made in America to improve the keeping quality of farmers' cream

intended for butter-making by the addition of salt. Trials made here have shown that, although bacterial deterioration could be largely controlled, oxidative taints became very evident and were often more objectionable than those due to bacteria.

Pure butter-fat is not readily susceptible to bacterial action, and experiments are in progress on its keeping quality at room temperatures and its large-scale preparation and packing.

(vii) *Miscellaneous.*—Investigations on cream neutralization which were commenced last year in collaboration with officers of the School of Dairy Technology have been completed, and the results are now being published in the *Journal of the Department of Agriculture of Victoria.* Some work was done with officers of the Dairy Research Institute (New Zealand) and the School of Dairy Technology on the applicability to butter of the phosphatase test for the efficiency of pasteurization. It was found that the test was not applicable to butters made from creams pasteurized by the " flash " methods in general use in Australia and New Zealand.

Australia has developed a small export trade in frozen milk, and an investigation has been commenced on factors (particularly curd precipitation) causing the occasional deterioration of this product. Some laboratory work has also been done on cheese-drying with the object of preparing a concentrated food of good keeping quality ; several of the conditions that must be observed for satisfactory operation have been defined.

3. *Radio Research Board.*—The work of this Board has continued as in previous years with the co-operation of the Postmaster-General's Department, of the Universities of Sydney and Melbourne, and of the Commonwealth Solar Observatory. The staff, however, has been seriously reduced in number on account of transfers to other work of more direct bearing on the national defence effort.

At the Sydney end, activities have been confined principally to the continuous recording of the characteristics of the ionosphere and to the application of the knowledge so obtained to the improvement of short-wave communication. The work involved is carried out at three centres, viz., the Commonwealth Solar Observatory (Mount Stromlo), Liverpool (near Sydney), and the University of Sydney. At Mount Stromlo, the series of P'f observations that were commenced in March, 1937, have been continued without interruption, using an improved model of the original type of recorder. One of these recorders was taken by an officer of the Observatory to South Africa during the solar eclipse of 1st October, 1940, and gave valuable data for comparing with simultaneous observations made at Watheroo, Mount Stromlo, and Liverpool. Steady changes in ionospheric conditions throughout the year have made it necessary to arrange for the inclusion of lower frequencies within the scope of the instrument. The work of modification is well in hand. At Liverpool, the construction of new fixed frequency transmitters for use in the P't observations has been completed ; they have given satisfactory performance during the past year.

As a result of all this work, average daily curves for all regions of the ionosphere for each month have been prepared, and from them it is possible to obtain a picture of normal propagation conditions via the ionosphere over southern Australia for all times of the day and night and for all seasons of the year ; moreover, it is possible to make accurate predictions of ionospheric conditions several months in advance.

The work in Melbourne was seriously handicapped by lack of personnel, and towards the end of the period under review the remaining investigator resigned and the investigations ceased.

4. *Mineragraphic Investigations.*—During the year, 39 investigations have been carried out into the mineral association of valuable minerals in ores, mill products, and residues submitted by mining companies and institutions. Each of these investigations was complete in itself and directed to some specific problem such as the mode of occurrence of gold and other valuable metals in an ore, concentrate, or tailing, particularly in relation to losses during treatment. Eighteen of these investigations have been concerned either with the mineral association in ores that have been subjected to experimental treatment in the ore-dressing laboratories, or with the examinations of test concentrates and tailings obtained thereby.

Among those of more general interest, an investigation of the cause of the high silver content in the bullion recovered by cyanide at Norseman, Western Australia, as compared with that of the gold recovered by strakes has led to the discovery of telluride minerals at Norseman. The silver telluride, hessite, and the lead telluride, altaite, are the more abundant, and the solution of hessite in cyanide accounts for most of the silver in the bullion. The gold-silver telluride, sylvanite, is also present in small quantities.

High-grade manganese ore from the Tamworth district, New South Wales, has been found to contain the iron-manganese mineral, jacobsite, which had not hitherto been known in Australia. Jacobsite occurs in seams in psilomelane and pyrolusite, and is a detriment to the use of the ore as " chemical manganese " in industry. It is, however, a magnetic mineral and can be readily separated by means of this property.

A comprehensive examination has been made of the mill products of the Lake George Mines, New South Wales, determining the proportions of free and combined particles of the valuable lead and zinc minerals in each product. It has demonstrated the intimate association of the valuable minerals with pyrite and gangue and the serious effect of the composite grains in limiting the grade of the lead and zinc concentrates, indicating that the problems of improvements in grade are primarily problems of fine grinding and classification.

These mineragraphic investigations have been facilitated by contributions from a number of mining companies through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting the investigators laboratory accommodation in the Geology School.

5. *Ore-dressing Investigations.*—Co-operative investigations have been continued in the laboratories at the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Department of Metallurgy of the University of Melbourne. These investigations have materially assisted in increasing Australian gold production.

During the past year, the Kalgoorlie laboratory issued twenty reports on investigations into gold ore treatment problems. Among these were investigations on behalf of the Mines Department of Western Australia, into the treatment of copper-gold ores of the Phillips River gold-field, and an investigation into the treatment of high-grade arsenical ore from Evanston on the Yilgarn gold-field. In addition, the precipitating action of charcoal on cyanide solutions containing gold and copper was investigated; as a result conditions governing the selective precipitation of the two metals were determined.

In Adelaide, although the laboratory is primarily concerned with gold ores, the war has given such special importance to various minerals that it was found advisable to devote a considerable amount of time to them. Particular mention may be made of graphite, of which there is a large deposit at Uley, South Australia, and of tungsten and zirconium. Examinations were also made of clays (for paper-making and for high-tension insulators), of tripoli, and of a glass sand.

At Melbourne, as in previous years, the bulk of the work has been in connexion with gold ores and their products. However, war conditions are reflected in the increased attention being paid to base metal deposits. The local demand for ferro-alloys and carbides for tools has resulted in attention being paid to tungsten, molybdenum, tantalite, and chromite ores; all these have been dealt with in the laboratory during the year. In addition, several tin ores have been investigated and a cinnabar deposit has been the subject of test work. In view of the shortage of mercury this latter investigation is considered to be of importance. The recently developed differential density or sink and float processes are receiving some attention from operators; to date only one ore has been tested using this process. A gold investigation of note was that conducted on the South Burnett battery tailings from Queensland. A characteristic of the ore was that portion of the gold was coated with an unidentified material making it refractory to both cyanidation and flotation. Roasting gave a satisfactory disruption of the coating. Important work was done on cyanidation residues from the Wiluna mine, Western Australia. A study of the location and nature of residual gold in this product showed that it is distributed between undecomposed sulphides and ferric oxide and that a large proportion is readily available by re-cyanidation. An increased demand for rutile, used in the production of welding electrodes, has resulted in a request for test work on Byron Bay zircon-rutile-ilmenite beach sands, and this work is now progressing.

6. *Biometrics.*—(i) *General.*—During the year, the head-quarters of the Biometrical Section have been transferred to Melbourne. The transfer was made following the resignation of the previous Officer-in-charge, subsequent to her marriage. A careful study of the position showed that the steadily-increasing scope of the work in all the various Divisions of the Council warranted the establishment of the head-quarters of the work at the Council's Head Office, Melbourne, from where the most effective control could be directed. As in the past, special officers are more or less permanently attached to some of the Divisions.

(ii) *Plant Industry.*—The Section has co-operated with officers of this Division in a wide range of investigations. The results of experimental work, begun in previous years, on the control of hoary cress, St. John's wort, and galvanized burr have been analysed, and a new experiment on the control of hoary cress in a wheat crop has been designed. Analyses of data obtained from experiments on pasture management have been made, and a system has been established for recording, cumulatively, the results of a field trial designed to compare rotational and continuous grazing. Investigations into take-all of wheat included a study of shoot-root relations in healthy and diseased plants and also an examination of the distribution of seedling-blighted plants in the field. The Section completed the analysis of a large correlation study of wheat designed to determine the influence that variation in sowing space of the parent generation has on the characteristics of the progeny; other work included the relation of floral position to

pod-setting in *Medicago* spp., the mechanism of transmission of the virus responsible for yellow dwarf disease of tobacco, and the design and analysis of trials with flax to investigate the effects of seeding rates and fertilizers on yield.

(iii) *Division of Economic Entomology.*—In this Division, statistical work included the analysis of data relating to the density of grasshopper populations, a determination of the effectiveness of various insecticidal dusts in weevil control, and an examination of the relation between the density of a red earth mite population and the yield of infested subterranean clover plants.

(iv) *Division of Forest Products.*—Statistical work has been principally concerned with the analysis of observational data obtained in studies of the mechanical properties of Australian timbers suitable for use in the production of aircraft, and with the planning of investigations and the analysis of experimental data relating to the manufacture and testing of paper pulp. In addition, a considerable amount of routine calculation has been completed for a number of Sections in the Division.

(v) *Division of Animal Health and Nutrition.*—Analyses have been made of results obtained in a variety of investigations ranging from field trials to laboratory experiments. Field trials included studies of the effects of drenching, as a means of controlling internal parasites, on sheep (" Frodsley ", Tasmania), the effect of improved pasture on sheep in Tasmanian conditions (" Valleyfield "), the efficiency of various anthelmintics, the effects of various methods of administering supplements in the prevention of peg-leg in cattle, and the relative efficacy of the Mules operation and Manchester's treatment in the prevention of blowfly strike (" Gilruth Plains "). Other work has involved epidemiological studies of rabbit myxomatosis and bovine mastitis. Laboratory work included analysis of data obtained in tests of harshness of wool and in the development of a technique for estimating the number of eggs of parasitic worms in fæcal material.

(vi) *Division of Industrial Chemistry.*—In connexion with the foundry sands investigations, advice has been given on the planning of experiments and the analysis of experimental data relating to the standardization of sieving practice, the calibration of sets of sieves, and the comparison of different test pieces used in foundry sands testing.

(vii) *Irrigation Research Station, Griffith.*—With the co-operation of the Bureau of Census and Statistics, Canberra, the primary data of the Griffith Horticultural Survey (*see* page 40) have been transferred to Hollerith cards, tabulated, and sorted. Statistics of damaged and healthy trees in relation to district, age, soil, slope, and flood condition have been obtained, and the Section is now engaged in completing an analysis which aims at relating the above statistics and in determining the influence of manures, irrigation practices, and soil condition on the health and yield of various crops.

The Section is also co-operating with the Research Station and the Water Conservation and Irrigation Commission of New South Wales in another research arising out of the damage caused by the 1939 flood. Rainfall data have been collected and an analysis is now in progress to determine the probability of occurrence of very wet and very dry winters in the Murrumbidgee irrigation area and its environs.

(viii) *Commonwealth Research Station, Merbein.*—Officers of this Station have been given assistance in connexion with the analysis of viticultural, wine-grape and reclamation trials, and the Section is now working on the problem of devising methods of analysis for data obtained in drainage investigations.

7. *Standards Association of Australia**.—A further year of war has resulted in an even greater proportion of the Association's efforts, now approximately 80 per cent., being devoted to problems specifically related to defence. The balance is that section of the peace time work which is of special urgency or of importance in the maintenance of industrial activity. About 130 Emergency Standards have been published, and an extensive programme of further work is in hand dealing principally with specifications for aircraft, ordnance, and general munition materials and equipment.

The impracticability of securing in Australia and New Zealand the large number of copies of British aircraft specifications required in connexion with aircraft production and maintenance has necessitated the reprinting of these locally. As there are over 1,000 of these publications the task is a heavy one. The Association already has in hand the work of reprinting a large section of these on behalf of the Government and will probably be recognized more and more as the agency for undertaking all such work. The needs of New Zealand are being provided for in this connexion.

* This Association is an independent body which is financially supported by contributions from Governments and Industries. The Council for Scientific and Industrial Research Acts as the liaison body between the Association and its main contributor—the Commonwealth Government.

The library information service continues to expand and is now recognized as an invaluable asset both by departmental officers and by industrial executives.

As the Association's war work has developed and its value has won recognition, requests for the undertaking of new tasks have flowed in to an extent which has overtaxed the existing staff capacity. When the position became acute, some relief was afforded by a special grant of funds from the Ministry of Munitions, which has made possible the appointment of further technical staff. A much greater expansion is essential, however, if the work now in hand or definitely in prospect is to be carried through expeditiously. It is anticipated that this will be made possible by additional subsidy from the Commonwealth Government and by greatly increasing revenue from subscriptions from private enterprise.

XIV. INFORMATION SECTION.

1. *General.*—As compared with the previous year, there has been an increased demand for the services of the Information Section by industrialists and business organizations and their scientific investigators, as well as by investigators of the Council's own staff. In particular, with the rapidly growing diversity of Australian manufacturing production, some manufacturers have wanted to know all that it is possible to comb from the literature on products new to Australia. Others have wanted all the information possible having a bearing on the substitution of an Australian raw material for a material that was formerly imported. Yet others have used the Section to obtain information on modifications of their methods likely to be of value. The services of the Section have also been used in answering a number of inquiries relating to the national defence effort.

The experience involved in meeting these demands has made clear the need for a specially trained staff such as the Section now has. In short, so many countries are now engaged on scientific work that information of value is, in itself, scattered through such an enormous number of journals, bulletins, and other reports that it requires specialized experience in the use of literature to ensure that all possible sources have been explored; without a thorough exploration useful information may easily be missed.

During the year, some 1,300 inquiries, as compared with 950 in the previous year, were dealt with; the following is a selection taken from them :—

(*a*) *Primary Industries.*—Wool-fat, sheep branding fluids, clarification of honey, copra utilization, cork, olive growing, peanuts, shark products, cheese, wool scouring, ramie fibre, flax retting, fibre from banana plants, soya bean, foxgloves, utilization of waste apples, carob bean tree, ginger, clothes moths, apple pomace, steam-tainted butter.

(*b*) *Manufactures.*—Resinoid grinding wheels, citric acid from lemons, egg albumen, rennet, carbon electrodes, dried meat, chlorophyll, activated carbon, power alcohol, dried milk, iron oxide pigments, vitamin B_1, morphine, anti-fouling paints, dextrose, dried eggs, margarine, oiled silk, caffeine, grape-seed oil, micanite, pectin, lemon oil, mineral wool, dolls' heads, artificial cryolite, rubber erasers, sintered bronze bearings, acid resisting cements, plasmon.

(*c*) *Industrial Minerals and Chemicals.*—Aluminium, magnesium powder, hafnium, sodium silicate, sodium sulphide, formic acid, hydrogen peroxide, ferro-silicon, production of hydrogen by electrolysis, potassium sulphate, potassium permanganate, benzaldehyde, calcium silicide, zircon, asbestos, mica, silicon tetrachloride, lead arsenate, arsenic pentoxide, glycol, acetone, furfural, hexachlorethane, sulphanilamide, cellulose acetate, pyrophoric materials, bronze powder, vermiculite, talc, magnesium chloride, tin recovery from scrap, alunite, zinc chloride, tantalite, lithium chloride, serpentine, sodium carbonate, rutile, silicon.

(*d*) *Miscellaneous.*—Substitutes for carnauba wax, tinning and brazing cast iron, hot-tinning copper, removing antimony from metal scrap, substitutes for baking powder, refrigerators, waterproofing leather and textiles, coke breeze, hard chromium plating, preservation of hessian, glazing porcelain, lead-coating steel, oaten flour for preventing rancidity, effluents from alcohol distilleries, cadmium plating, hydrogenation of cotton-seed oil, rolling aluminium and zinc sheet, lubricants for launching ships, substitutes for olive oil, cleaning aluminium, rustproofing steel, gaskets and packings, anodizing aluminium, cellular concrete, drying agents, tanning and dyeing sheep pelts.

Apart from the giving out of information, the other functions of the Section are, briefly, the preparation and publication of articles, so far as practicable in non-scientific terms, explaining the objects and results of researches undertaken by the Council; the preparation and issue from time to time to members of the Council, its committees, senior members of its staff, and corresponding bodies in other parts of the Empire confidential statements summarizing the reports received on the Council's work; the preparation and issue to the press of statements concerning the work of the Council; the editing and publication of the Council's Journal,

bulletins, pamphlets, annual reports, and other publications; the distribution of the Council's publications; the preparation and collection of exhibits demonstrating the work of the Council; and the provision of secretarial services to committees of the Council.

During the past year, it was impracticable to give much attention to some of these activities so great was the demand for information. With the growth of the Council's work, the editing and distribution of publications has increased, and during the year the mechanization of the various mailing lists of people to receive different types of publications was practically completed.

2. *Library.*—The Council's library, which, taken as a whole, is perhaps one of the most extensive scientific libraries in the Commonwealth, continues to develop. That portion of it maintained at the Council's Head Office serves as the main working tool of the Information Section, and specializes particularly in the subjects of chemical technology, metallurgy, textiles, and other matters relating to the secondary industries. In this particular portion of the library emphasis is laid on the collection of journals, periodicals, and occasional publications of research laboratories in Government Departments, and particularly of indexing journals and bibliographies. In this way, a volume of material from which references on any matter that arises may be rapidly obtained is being accumulated. A feature of the year has been the extent to which the library staff has been called on to give advice and assistance in the organization of other technical libraries, quite a few of which are now being established by public and semi-public bodies and by private firms.

3. *Photographic Copying.*—The number of photographic copies of scientific articles and reports that have been distributed in response to scientific requests has increased considerably; during the year, some 11,000 pages of material were distributed in this way, as compared with 3,000 in the previous year. Such a service is of particular value to technologists and investigators in a country like Australia, where workers are often isolated and where access to some of the scientific literature they desire to see is often difficult, if not impossible. The Section is not alone in its efforts in this direction, for one or two Australian public libraries are also installing photographic equipment, and they will thus be able to make their treasures available to a far wider circle than previously. Australia, however, has a long way to go before she will reach the desirable high plane of information development that Germany has attained. In that country it was planned to provide, not later than the end of 1940, no less than 100 of the larger libraries with photographic copying equipment, and these 100 and another 400 smaller libraries with the necessary reading equipment whereby the exceedingly cheap photographic film might be read, thus obviating much more expensive printed enlargements. Under this scheme, German scientific workers of every description must find it extraordinarily easy to get all the information they want at very short notice.

XV. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1940, to 30th June, 1941, is as follows:—

	£	£	£
(1) Salaries and contingencies	..	..	28,853*
(2) Remuneration of Chairman and Members of Council ..	..	..	2,450†
(3) Investigations—			
(i) Animal Problems—			
(*a*) Sheep diseases: foot-rot, black disease, preputial disease, caseous lymphadenitis, entero-toxaemia, pregnancy disease and equine navel ill (at Animal Health Laboratory, Parkville, Victoria) ..	..	6,854	
(*b*) Mastitis (Victoria)	4,302		
Less contribution from Australian Cattle Research Association and part Berwick Farm Revenue ..	4,302		
	———	..	
(*c*) Rabbit myxomatosis (at Animal Health Laboratory, Parkville, Victoria, and Point Pearce, South Australia) ..	572		
Less contribution from Australian Wool Board	300		
	———	272	

* The main items of expenditure under this heading are salaries of the Administrative staff at the Council's Head Office; staff and upkeep of State Committees; part salary of representative at Australia House; travelling expenses of Head Office staff, members of the Council, &c., and printing and general office expenditure.
† Provided from Consolidated Revenue Fund.

(3) Investigations—*continued.*	£	£	£
(i) Animal Problems—*continued.*			
(*d*) Tick and tick fevers, pleuro-pneumonia, &c., (at Animal Health Laboratory, Parkville, Victoria, and Field Stations at Tooradin, Koo-Wee-Rup, Victoria, and Helenslee, Queensland)	7,047		
Less contributions from Queensland Government, part proceeds from sale of vaccine, and C.P.P. Revenue Fund	3,260		
		3,787	
(*e*) Hæmaturia (Victoria and South Australia) ..	..	171	
(*f*) Toxaemic jaundice (at Animal Health Laboratory, Parkville, Victoria, and Field Station, Barooga, New South Wales) ..	485		
Less contributions from Toxaemic Jaundice Revenue Fund, Australian Wool Board and Australian Meat Board	390		
		95	
(*g*) Oestrus experiment and anaplasmosis at Werribee Field Station, Victoria ..	943		
Less contribution from Oestrus Revenue Account	122		
		821	
(*h*) Parasitology (at McMaster Laboratory, University of Sydney)	11,101		
Less contributions from George Aitken Pastoral Research Trust, University of Sydney, and Australian Wool Board..	1,700		
		9,401	
(*i*) Bacteriology (at McMaster Laboratory, University of Sydney)	1,793		
Less contributions from University of Sydney, George Aitken Pastoral Research Trust, and Australian Wool Board	500		
		1,293	
(*j*) Biochemical problems (at McMaster Laboratory, University of Sydney) ..	1,581		
Less contributions from Australian Wool Board..	800		
		781	
(*k*) Parasitology and genetics (at F. D. McMaster Field Station, St. Mary's, New South Wales)	4,173		
Less contributions from Australian Wool Board, University of Sydney, Thorpes Ltd., and Infertility Revenue Fund	1,062		
		3,111	
(*l*) External parasites (at McMaster Laboratory, University of Sydney)	172		
Less contributions from Australian Wool Board..	172		
		..	
(*m*) Wool research (at McMaster Laboratory, University of Sydney)	..	520	

	£	£	£
(3) Investigations—*continued.*			
(i) Animal Problems—*continued.*			
(*n*) Wool biology (at McMaster Laboratory, University of Sydney)	891		
Less contributions from Australian Wool Board..	891		
		..	
(*o*) National Field Station "Gilruth Plains", Cunnamulla, Queensland	5,735		
Less contributions by Australian Wool Board, Commonwealth Bank, George Aitken Pastoral Research Trust, and Station Revenue Account	5,735		
		..	
(*p*) Entero-toxaemia (braxy-like disease), Moora (Gingin) disease, ataxia in lambs, &c. (Western Australia)	..	465	
(*q*) Biochemical and Agrostological Studies (at Animal Nutrition Laboratory, Adelaide, and Field Stations, Robe, South Australia, and Wambanumba, New South Wales)..	11,288		
Less contributions from George Aitken Pastoral Research Trust and Nutrition Revenue Account ..	558		
		10,730	
(*r*) Feeding Experiments (at Waite Agricultural Research Institute, Glen Osmond, South Australia)	1,136		
Less contributions from George Aitken Pastoral Research Trust ..	100		
		1,036	
(*s*) Field Experiments on Mineral Supplements (at Field Stations, Wambanumba, New South Wales; Penola, South Australia; and Robe, South Australia)	1,147		
Less contributions from George Aitken Pastoral Research Trust ..	300		
		847	
(*t*) Drought Feeding, Nutrition and Wool Production (at Animal Nutrition Laboratory, Adelaide)	2,174		
Less contributions from Australian Wool Board	2,174		
		..	
(*u*) Blowfly School	97		
Less contribution from Australian Wool Board..	97		
		..	
(*v*) Suspense account	..	329	
(*w*) Central Office	..	4,693	
		45,206	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	9,000	
			36,206

(3) Investigations—*continued.*	£	£	£
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,498		
Capital	249		
		5,747	
(*b*) Experimental plots	..	531	
(*c*) Plant pathology	..	3,865	
(*d*) Plant genetics	..	5,344	
(*e*) Herbarium	..	276	
(*f*) Fibre investigations	..	883	
(*g*) Plant introduction	..	4,761	
(*h*) Apple rootstocks, Stanthorpe, Queensland ..	..	867	
(*i*) Fruit problems	..	2,931	
(*j*) Agrostology	7,541		
Less contributions from Australian Wool Board	2,517		
		5,024	
(*k*) Field Experiment Stations, Canberra ..	2,477		
Less contribution from Tobacco Trust Fund	207		
		2,270	
(*l*) Tobacco investigations	3,136		
Less contributions from Tobacco Trust Fund	3,136		
(*m*) Water weeds and hoary cress, Victoria ..	606		
Less contributions from New South Wales Water Conservation and Irrigation Commission, and Victorian State Rivers and Water Supply Commission	500		
		106	
(*n*) Medicinal Plants	419		
Less contributions from Department of Supply and Development ..	419		
		..	
(*o*) Suspense account	..	40	
			32,645
(iii) Entomological Problems—Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	4,308		
Capital	754		
	5,062		
Less contributions from Australian Wool Board	400		
		4,662	
(*b*) Museum and technical services	..	1,257	
(*c*) Biological control (Australia)	..	727	
(*d*) Biological control (France and England) ..	..	525	
(*e*) Biological control (America)	..	1,364	
(*f*) Biological control (India)	..	949	
(*g*) Locust investigations	..	2,267	
(*h*) Earth mite investigations	..	728	
(*i*) Termite investigations	..	3,338	
(*j*) Physiology and toxicology	..	1,435	
(*k*) Cattle tick	..	490	

	£	£	£
(3) Investigations—*continued.*			
(iii) Entomological Problems—Division of Economic Entomology—*continued.*			
(*l*) Blowfly investigations	..	1,406	
(*m*) Oriental peach moth	647		
Less contributions from Department of Agriculture, Victoria	369		
		278	
(*n*) Wheat infestation	423		
Less contributions from Australian Wheat Board	421		
		2	
(*o*) Prickly Pear investigations	573		
Less contributions from Commonwealth Bank	573		
		..	
(*p*) Cotton investigations	442		
Less contributions from Ministry of Agriculture, Egypt	396		
		46	
(*q*) Suspense account	..	260	
			19,734
(iv) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals	6,835		
Capital	1,043		
	7,878		
Less funds provided from Station Revenue	1,671		
	6,207		
Less contributions by New South Wales Water Conservation and Irrigation Commission ..	1,500		
		4,707	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals	6,455		
Capital	609		
	7,064		
Less funds provided from Station Revenue	589		
	6,475		
Less contributions by Dried Fruits Control Board and Nyah-Woorinen Dried Fruits Enquiry Committee	1,560		
		4,915	
(*c*) Ripening, processing, &c., of vine fruits, Mildura District	833		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., and Aurora Packing Pty. Ltd.	833		
		..	
			9,622

(3) Investigations—*continued.*	£	£	£
(v) Soil Problems—			
(*a*) Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia—			
Annual	11,464		
Capital	363		
		11,827	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	2,500	
			9,327
(vi) Food Preservation and Transport—			
(*a*) Central Laboratory, Homebush, New South Wales—			
Annual	3,581		
Capital	382		
	3,963		
Less contributions from Revenue Account	103		
		3,860	
(*b*) Meat investigations, Homebush, New South Wales	915		
Less contributions by Australian Meat Board and Metropolitan Meat Industry Commissioner, New South Wales	908		
		7	
(*c*) Fish investigations, Homebush, New South Wales		1,930	
(*d*) Non-tropical fruits, Homebush, New South Wales	2,035		
Less contributions from New South Wales Department of Agriculture	1,000		
		1,035	
(*e*) Physics and Transport, Homebush, New South Wales	..	1,754	
(*f*) Citrus preservation	..	575	
(*g*) Microbiology	..	624	
(*h*) Meat investigations, Brisbane Abattoir ..	990		
Less contributions by Queensland Meat Industry Board	850		
		140	
(*i*) Egg investigations	1,330		
Less contributions from Egg Producers' Council	665		
		665	
(*j*) Non-tropical fruits, Melbourne	..	769	
(*k*) Fruit juice investigations, Homebush, New South Wales	2,341		
Less contributions from various contributors and Revenue Account ..	252		
		2,089	
(*l*) Apple juice certification	165		
Less contributions from Apple and Pear Board..	165		
		..	
(*m*) Adviser on Food Preservation	..	150	
(*n*) Suspense Account	..	123	
		13,721	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	2,000	
			11,721

(3) Investigations—*continued.*	£	£	£
(vii) Forest Products—			
(*a*) Central Laboratory—			
Annual	10,849		
Capital	575		
		11,424	
(*b*) Seasoning	..	2,250	
(*c*) Preservation	..	1,362	
(*d*) Chemistry	2,628		
Less contributions from Australian Paper Manufacturers Limited, Associated Pulp and Paper Mills Ltd., and Australian Newsprint Mills Pty. Ltd.	1,500		
		1,128	
(*e*) Creosote investigations	671		
Less contributions from Tar Distillery Industry	671		
		..	
(*f*) Aircraft timber	5,142		
Less various contributions	17		
		5,125	
(*g*) Flax processing	51		
Less contributions from Department of Supply and Development ..	51		
		..	
(*h*) Wood structure	3,008		
Less contributions from Bureau of Forestry, Canberra, and Queensland, New South Wales, Victorian and Western Australian Forests Services	115		
		2,893	
(*i*) Mechanics	..	2,447	
(*j*) Utilization	..	2,056	
(*k*) Physics	..	1,166	
(*l*) Fibres	..	1,042	
(*m*) Statistics and computing	..	270	
(*n*) Veneer and gluing	1,339		
Less various contributions	17		
		1,322	
(*o*) Suspense Account	..	466	
		32,951	
Less miscellaneous contributions ..	..	98	
		32,853	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	1,500	
			31,353
(viii) Mining and Metallurgy—			
(*a*) Mineragraphic investigations	..	790	
Less contribution by Australasian Institute of Mining and Metallurgy	..	368	
			422
(ix) Radio Research—			
(*a*) Melbourne and Sydney Universities ..	4,413		
Less contributions by Postmaster-General's Department	3,202		
		1,211	
(*b*) Advisers on radio research	..	64	
			1,275

(3) Investigations—*continued.*	£	£	£
(x) Information Service including Library		..	4,898
(xi) Gold Mining—			
(*a*) Mineragraphic investigations, Melbourne University		798	
(*b*) Ore-dressing, Melbourne University		1,323	
(*c*) Ore-dressing, South Australian School of Mines ..		836	
(*d*) Ore-dressing, Kalgoorlie School of Mines		463	
(*e*) Advisory Committee		2	
(*f*) Suspense account		62	
			3,484
(xii) Fisheries Investigations—			
(*a*) Administrative—			
Annual	5,257		
Capital	603		
		5,860	
(*b*) Marine biology		3,125	
(*c*) Marine bacteriology		739	
(*d*) Chemistry (including fish and by-product analyses) and hydrology		474	
(*e*) Investigations at sea		9,632	
(*f*) Fish liver oils		224	
(*g*) Co-operative investigations with New South Wales		4	
(*h*) Suspense account		18	
			20,076
(xiii) Apple and Pear Investigations—			
(*a*) Grants to States		4,654	
(*b*) Codling Moth		45	
(*c*) Waxy coatings of apples and pears		55	
		4,754	
Less contributions from Department of Commerce		4,754	
			..
(xiv) Aeronautical Research—			
(*a*) Administrative—			
Annual	5,323		
Capital	5,910		
		11,233	
(*b*) Workshop		2,975	
(*c*) Instrument Section		580	
(*d*) Structure and materials		2,342	
(*e*) Engine and fuels		1,613	
(*f*) Aerodynamics		1,286	
(*g*) Suspense account		292	
			20,321
(xv) National Standards Laboratory—			
(*a*) Administrative—			
Annual	6,999		
Capital	3,234		
		10,233	
(*b*) Physics	4,581		
Less contributions	4		
		4,577	
(*c*) Electrical	..	4,122	
(*d*) Metrology	16,894		
Less contributions	2,667		
		14,227	
(*e*) Testing co-ordination	..	805	
(*f*) Suspense account	..	4,906	
			38,870

(3) Investigations—*continued.*	£	£	£
(xvi) Industrial Chemistry—			
(*a*) Administrative—			
Annual	6,144		
Capital	1,089		
		7,233	
(*b*) Leather	..	598	
(*c*) Wool	..	1,217	
(*d*) Minerals and metals	..	662	
(*e*) Dairy products	..	340	
(*f*) Foundry sands	..	784	
(*g*) Producer gas	..	226	
(*h*) Alunite	..	472	
(*i*) Suspense account	..	181	
			11,713
(xvii) Training of Students—Secondary Industry Research	..	..	1,260
(xviii) Miscellaneous—			
(*a*) Tomato wilt	..	282	
(*b*) Mineral deficiency in pastures	..	971	
(*c*) Dairy research	..	2,490	
(*d*) Statistical section	..	1,959	
(*e*) Grant for mineral deficiencies in Western Australia	..	100	
(*f*) Lubricants and bearings	5,336		
Less contribution from University of Melbourne	599		
		4,737	
(*g*) Evaporation from ponds	50		
Less contribution from Australian Wool Board..	50		
		..	
(*h*) Various	..	512	
			11,051
Total of Item 3—Investigations ..	..	..	263,978

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1940–41 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled " The Specific Purposes Trust Account " :—

	Receipts 1940–41 and balances brought forward from 1939–40. £		Expenditure 1940–41. £
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear, and Forest Products Investigations)	16,300	..	16,073
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	12,141	..	10,043
Australian Cattle Research Association (Mastitis Investigations)	4,289	..	4,289
George Aitken Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,000	..	2 000
Queensland Government Cattle Research (Animal Health and Nutrition Investigations)	1,000	..	1,000
University of Sydney (Animal Health and Nutrition Investigations)	355	..	*355
Australian Meat Board (Toxaemic jaundice investigations, Barooga, New South Wales)	153	..	153
Thorpes Ltd., F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	187	..	160
Carried forward	36,425	..	34,073

* Includes £25 on account 1939–40 expenditure.

	Receipts 1940–41 and balances brought forward from 1939–40.	Expenditure 1940–41.
	£	£
Brought forward	36,425	34,073
New South Wales Water Conservation and Irrigation Commission (Cumbungi Investigations)	317	250
Victorian State Rivers and Water Supply Commission (Cumbungi Investigations)	342	250
Victorian Central Citrus Association—Citrus Problems (Plant Industry Investigations)	100	..
Tobacco Trust Fund—Prime Minister's Department—Tobacco Problems (Plant Industry Investigations)	11,565	3,342
Department of Supply and Development—Medicinal Plants (Plant Industry Investigations)	500	419
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Ministry of Agriculture, Egypt—Cotton Investigations Entomological Investigations)	396	396
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	485	*485
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	369	369
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,000	1,500
Australian Dried Fruits Association, Red Cliffs Branch (Soils Investigations)	113	113
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	212	208
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	212	208
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	212	208
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	212	208
Dried Fruits Control Board (Dried Fruits Investigations)	1,500	1,500
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	60	60
Australian Meat Board (Meat Investigations) ..	500	454
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	500	454
Queensland Meat Industry Board (Meat Investigations)	850	850
Apple and Pear Marketing Board—Apple Juice Certification (Food Preservation Investigations)	180	165
New South Wales Department of Agriculture (Food Investigations)	1,000	1,000
Leeton Co-op. Cannery Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations) ..	11	11
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	20	10
Lewis Berger & Sons Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations) ..	25	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	836	665
Egg Producers' Council (Watery Whites in Eggs) ..	2	..
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	500	500
Carried forward	59,536	47,698

* Includes £65 on account of 1939–40 expenditure.

	Receipts 1940–41 and balances brought forward from 1939–40.	Expenditure 1940–41.
	£	£
Brought forward	59,536	47,698
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500	500
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales, and Western Australia — Wood Structure (Forest Products Investigations)	125	115
Tar Distillers Research Committee (Creosote Investigations)—Division of Forest Products	692	671
Sundry Contributors (Forests Product Investigations) ..	1,699	98
Australian Dairy Council (Wood Taint in Butter Investigations)	20	..
Department of Supply and Development—Flax Processing (Forest Products Investigations) ..	800	51
R. J. Howard (Division of Forest Products—Aircraft Timber Research)	17	17
Hardy's Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work)	11	11
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work) ..	14	6
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	552	*552
Postmaster-General's Department (Radio Research) ..	3,202	3,202
Department of Commerce (Apple and Pear Investigations)	5,552	4,754
Government of New South Wales	8,000	8,000
Ministry of Munitions	3,451	2,667
Ministry of Munitions	75	4
Sundry Contributors (Council for Scientific and Industrial Research (Publications)	7	..
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35	..
F. Walton & Co. (Division of Industrial Chemistry) ..	10	..
Associated Woollen and Worsted Textile Manufacturers of Australia (Division of Industrial Chemistry) ..	500	..
University of Melbourne (Friction Research)	599	599
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	104	62
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Nutrition Investigations)	1,057	651
Revenue Fund—Oestrus Experiment (Animal Health and Nutrition Investigations)	122	122
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	3,126	1,609
Revenue Fund—Anaplasmosis Investigations (Animal Health and Nutrition Investigations)	26	..
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	106	..
Revenue Fund—Werribee Farm (Mastitis Investigations)	1,064	13
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	4,426	4,030
Carried forward	95,928	75,932

* Includes £184 on account of 1939–40 expenditure.

	Receipts 1940–41 and balances brought forward from 1939–40.		Expenditure 1940-41.
	£		£
Brought forward	95,928	..	75,932
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	382	..	..
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations)	30	..	..
Revenue Fund—Parasitological Investigations (Animal Health and Nutrition Investigations)	81	..	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	920	..	372
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	537	..	58
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Nutrition Investigations)	352	..	40
Revenue Fund—Plant Industry Investigations ..	26	..	..
Revenue Fund—Entomological Investigations ..	274	..	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	3,533	..	1,671
Revenue Fund—Merbein Research Station (Viticultural Investigations)	4,909	..	589
Revenue Fund—Citrus Preservation Investigations ..	321	..	231
Revenue Fund—Division of Food Preservation and Transport	178	..	103
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	55	..	..
Revenue Fund—Mining and Metallurgy	3	..	..
Revenue Fund—Ore-dressing Investigations	576	..	..
Revenue Fund—Division of Aeronautics	51	..	..
Revenue Fund—National Standards Laboratory ..	27	..	..
Revenue Fund—Dairy Investigations	1	..	..
	108,184	..	78,996

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1941. The list does not include typists, laboratory assistants, and miscellaneous workers.

1, Head Office Staff.

Chief Executive Officer—Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., F.A.C.I.
Deputy Chief Executive Officer—A. E. V. Richardson, C.M.G., M.A., D.Sc.
Secretary—G. Lightfoot, M.A.
Assistant Secretary and Officer-in-Charge, Information Section—G. A. Cook, M.Sc. B.M.E., F.A.C.I.
Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A. (*vice* H. P. Breen, A.I.C.A., seconded).

Information Section—

J. E. Cummins, B.Sc., M.S., F.A.C.I.
F. G. Nicholls, M.Sc., A.A.C.I. (seconded).
N. C. Hancox, M.Sc., A.A.C.I.
Miss M. E. Hamilton, B.Sc.
R. J. L. Martin, M.Sc., A.A.C.I.
A. G. Tregea, M.Sc., A.A.C.I.
Miss J. Dunstone, B.Sc.

Library—

Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.

Accounts, Stores—
Accountant—D. J. Bryant, A.F.I.A. (*vice* M. G. Grace, A.I.C.A.).
R. W. Viney, A.I.C.A.
M. A. Elliott.
V. Leonard.
C. Munro.
J. Farey.
F. J. Whitty.
R. Bennett.
J. Bourne.
C. Garrow.
C. Cole.
K. Gamble.
H. Lee.
J. M. Short.
K. J. Fogarty.

Orders and Transport—
J. M. Derum.
L. Graham.

Staff—
R. D. Elder.
J. Smithwick (on military leave—R.A.A.F.).

Records—
P. Domec-Carre.
P. Knuckey.
R. McVilly, A.F.I.A.
F. Butler.
B. Gooley (on military leave—R.A.A.F.).
B. Gaynor.
M. Combe (on military leave—R.A.A.F.).
M. Reynolds.
Miss G. Shem, B.A.
Miss W. Livingstone.
D. Yarr.

Head Typiste—
Miss B. M. Thomas.

Clerical Assistant to Chief Executive Officer—Miss A. Slattery, B.A.
Clerical Assistant to Chairman—Mrs. N. E. Roberts.
Clerical Assistant to Deputy Chief Executive Officer—Miss J. L. Thomas.
Senior Clerical Officer, Sydney—R. F. Williams.
Architect—W. R. Ferguson, B.E., A.R.A.I.A.

2. Secretaries of State Committees.

New South Wales—
Mrs. N. E. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.

Victoria—
G. A. Cook, M.Sc., B.M.E., F.A.C.I., 314 Albert-street, East Melbourne.

Queensland—
Miss H. F. Todd, 113 Eagle-street, Brisbane.

South Australia—
J. Ward Walters, Animal Nutrition Laboratory, University of Adelaide.

Western Australia—
R. P. Roberts, B.Sc., Institute of Agriculture, University of Western Australia.

Tasmania—
F. J. Carter, c/o Premier's Office, Hobart.

3. Australia House, London.

Representative in Britain—F. L. McDougall, C.M.G. (part-time).

4. Division of Plant Industry.

At Canberra—

Administration—
Chief—B. T. Dickson, B.A., Ph.D.
Librarian (half-time)—Miss E. Mollison.
Clerk-in-Charge (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on military leave—A.I.F.)

Pathology—
Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Research Officer—W. V. Ludbrook, B.Agr.Sc., Ph.D.
Assistant Research Officer—N. H. White, M.Sc.
Assistant Research Officer—D. O. Norris, B.Sc.Agr.

Genetics—
Senior Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S.
Assistant Research Officer—F. W. Hely, B.Sc.Agr.
Assistant Research Officer—E. M. Hutton, M.Sc.Agr.
Technical Officer—S. G. Gray, B.Sc.Agr.

Plant Introduction—
Senior Research Officer—A. McTaggart, B.S.A., M.S.A., Ph.D.
Assistant Research Officer—W. Hartley, B.A., Dip.Ed.

Horticultural and General Botany—
Senior Research Officer—C. Barnard, D.Sc.

Vegetable Fibre Investigations—
Assistant Research Officer—J. Calvert, D.Sc., F.L.S.

Agrostology—
Senior Research Officer—J. G. Davies, B.Sc., Ph.D.
Assistant Research Officer—C. M. Donald, B.Agr.Sc.
Assistant Research Officer—R. Roe, B.Sc.Agr.
Assistant Research Officer—R. M. Moore, B.Sc.Agr.
Assistant Research Officer—N. Shaw, B.Sc.Agr.
Assistant Research Officer—T. Wilkinson, B.Sc. (on military leave—A.I.F.).
Assistant Research Officer—W. M. Willoughby, B.Sc.Agr.
Technical Officer—E. H. Kipps, B.Sc.
Technical Officer—Miss N. Barrie, B.Sc.Agr.

Tobacco Investigations—
Research Officer (pathology)—A. V. Hill, M.Agr.Sc.
Technical Officer (quality)—G. H. Marks.
Assistant Research Officer (pathology)—K. F. Plomley, B.Sc.Agr.

At Waite Agricultural Research Institute—
Technical Officer (tobacco physiology)—Miss J. McPherson, B.Sc.

At Moss Vale, New South Wales—
Assistant Research Officer (genetics)—K. L. Hills, B.Agr.Sc.

At Griffith, New South Wales—
Assistant Research Officer (horticultural physiology)—Miss J. Hearman, B.Sc., Ph.D.

At Queensland Agricultural High School and College, Lawes—
Research Officer (genetics)—C. S. Christian, B.Sc.Agr., M.Sc.
Assistant Research Officer (plant introduction)—T. B. Paltridge, B.Sc.

At Stanthorpe, Queensland—
Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.

At Fitzroyvale, Central Queensland—
Assistant Research Officer (plant introduction)—J. F. Miles, B.Sc.Agr.
Assistant Research Officer (plant introduction)—E. T. Bailey, B.Sc.

At University of Melbourne—
Assistant Research Officer (weeds investigations)—R. W. Prunster, B.Sc. (Agric.).

At University of Tasmania, Hobart—
Research Officer (fruit investigations)—D. Martin, B.Sc.

At University of Western Australia, Perth—
Research Officer (agrostology)—A. B. Cashmore, M.Sc.
Assistant Research Officer (agrostology)—R. C. Rossiter, B.Sc.Agr.

5. Division of Economic Entomology.

At Canberra—

Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Miss E. Mollison.
Clerk-in-Charge (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on military leave—A.I.F.).

Pests of Stored Wheat Investigations—
Senior Research Officer—F. N. Ratcliffe, B.A.
Assistant Research Officer—F. J. Gay, B.Sc., D.I.C.
Technical Officer—T. Greaves.

Insecticide Investigations—
Assistant Research Officer—J. S. Fitzgerald, M.Sc., Ph.D., D.I.C., A.A.I.C.

Forest Entomology—
Senior Research Officer—G. F. Hill.

Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M. (on military leave—A.I.F.).
Assistant Research Officer (blowfly investigations)—Mrs. M. J. Mackerras, M.Sc., M.B. (on extended leave).
Assistant Research Officer (blowfly investigations)—D. F. Waterhouse, M.Sc., A.A.C.I.
Assistant Research Officer (blowfly investigations)—D. Gilmour, M.Sc.
Agricultural Entomology and Museum—
Assistant Research Officer—T. G. Campbell.
Assistant Research Officer—F. Wilson.
Technical Officer (photographer)—W. J. James.
Locust Investigations—
Assistant Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.

At Warren, New South Wales—
Assistant Research Officer (locust investigations)—L. R. Clark, M.Sc.
Technical Officer (locust investigations)—D. L. Hall, Dip.Agr.

At School of Veterinary Science, Brisbane—
Senior Research Officer (cattle tick investigations)—L. F. Hitchcock, M.Sc.

At Katanning, Western Australia—
Assistant Research Officer (earth mite investigations)—K. R. Norris, M.Sc.

At Mooroopna, Victoria—
Assistant Research Officer (peach moth investigations)—G. A. H. Helson, M.Sc.

6. Division of Animal Health and Nutrition.

At Animal Health Research Laboratory and Divisional Head-quarters, Melbourne—
Chief—L. B. Bull, D.V.Sc.
Divisional Secretary—A. J. Vasey, B.Agr.Sc.
Chief Bacteriologist and Officer-in-Charge—A. W. Turner, D.Sc., D.V.Sc., O.B.E.
Senior Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane. B.V.Sc.
Senior Research Officer (pathology, bacteriology)—C. G. Dickinson, B.V.Sc.
Senior Research Officer (serological investigations)—A. D. Campbell, B.V.Sc.
Research Officer (immuno-chemistry)—A. T. Dann, M.Sc., A.A.C.I.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F.
Research Officer (bacteriology—biochemistry)—A. T. Dick, M.Sc., A.A.C.I.
Assistant Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc.
Assistant Research Officer (field studies, dairy cattle diseases)—L. Duckett, Dr.Med.Vet. (Brno).
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss M. J. Monsbourgh, B.Sc.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer.
Librarian—Miss F. V. Murray, M.Sc. (part-time).
Clerk—J. Foley.

At F. D. McMaster Animal Health Laboratory, Sydney—
Officer-in-Charge—D. A. Gill, M.R.C.V.S., D.V.S.M.
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc. (on military leave—A.I.F.).
Senior Research Officer (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc. Ph.D.(Cantab.), A.I.C.
Senior Research Officer (bacteriology, sheep diseaes)—W. I. B. Beveridge, D.V.Sc.
Research Officer (parasitology)—G. Kauzal, Dr.Vet.Med.
Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Research Officer (chemistry of wool)—M. R. Freney, B.Sc., A.A.I.C.
Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (parasitology, field studies)—I. W. Montgomery, B.V.Sc.
Assistant Research Officer (blowfly strike, field studies)—I. L. Johnstone, B.V.Sc.

Assistant Research Officer (parasitology, field studies)—F. H. Ward, B.V.Sc.
Assistant Research Officer (biochemistry)—C. R. Austin, B.V.Sc. (part-time).
Technical Officer—E. Parrish.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Clerk—H. H. Wilson.

At Animal Nutrition Laboratory, Adelaide—
Chief Nutrition Officer and Officer-in-Charge—H. R. Marston, F.A.C.I.
Secretary—J. Ward Walters.
Senior Research Officer (metabolism)—E. W. L. Lines, B.Sc.
Research Officer (ruminant physiology)—R. H. Watson, B.Sc.Agr.
Research Officer (biochemistry)—J. W. H. Lugg, Ph.D., D.Sc., F.I.C., A.A.C.I.
Assistant Research Officer (biochemistry)—A. B. Beck, M.Sc., A.A.C.I.
Assistant Research Officer (agrostology)—D. S. Riceman, B.Agr.Sc.
Assistant Research Officer (mineral deficiency, field investigations)—H. J. Lee, B.Sc.
Assistant Research Officer (metabolism)—F. V. Gray, B.Sc. (on military leave—A.I.F.).
Assistant Research Officer (biochemistry)—Frau Ella Flaum, D.Sc.Agric. (Budapest).
Assistant Research Officer (metabolism)—T. A. F. Quinlan-Watson, B.Sc.
Technical Officer—J. O. Wilson.
Technical Officer—F. C. Farr (seconded).
Technical Officer—I. G. Jarrett, B.Sc.
Technical Officer—A. F. Pilgrim, B.Sc. (on military leave—R.A.N.).
Technical Officer—D. W. Dewey.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute, Adelaide—
Research Officer (studies in experimental nutrition)—A. W. Peirce, M.Sc., A.A.C.I.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Principal Research Officer and Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Assistant Research Officer (animal genetics, field investigations)—H. E. B. Shaw, B.V.Sc.
Technical Officer—C. R. Graham.

At National Field Station, "Gilruth Plains", Cunnamulla, Queensland—
Research Officer-in-Charge—J. A. Riches, B.Sc.Agr., Ph.D.
Station Manager—W. S. Firth.

At Institute of Agriculture, University of Western Australia—
Assistant Research Officer (biochemistry)—S. T. Evans, B.Sc., A.A.C.I.

7. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Assistant Research Officer (chemist)—R. E. Shapter, A.A.C.I.

8. Division of Soils.

At Waite Agricultural Research Institute—
Chief—J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Principal Research Officer (soil surveys)—J. K. Taylor, M.Sc., B.A.
Research Officer (soil surveys)—T. J. Marshall, M.Agr.Sc., Ph.D.
Research Officer (soil surveys)—C. G. Stephens, M.Sc., A.A.C.I.
Research Officer (soil chemistry)—J. S. Hosking, M.Sc., A.I.C., A.A.C.I.
Research Officer (soil chemistry)—A. Walkley, B.A., B.Sc., Ph.D., A.A.C.I.
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc.
Assistant Research Officer (microbiology)—T. H. Strong, B.Agr.Sc. (R.A.A.F Reserve).
Assistant Research Officer (soil surveys)—J. G. Baldwin, B.Agr.Sc. (on military leave—A.I.F.).
Assistant Research Officer (soil surveys)—G. D. Hubble, B.Agr.Sc. (seconded).
Assistant Research Officer (soil surveys and ecology)—R. L. Crocker, B.Sc. (seconded).

Assistant Research Officer (soil surveys)—B. E. Butler, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. Smith, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. I. Herriot, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.
Assistant Research Officer (soil surveys)—E. J. Johnston, B.Agr.Sc. (on military leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—T. Langford Smith, B.Sc.
Assistant Research Officer (soil surveys)—A. M. Acock, B.A., D.Phil. (Oxon.).
Technical Officer (surveys and cartography)—P. D. Hooper.
Technical Assistant (soil chemistry)—H. R. Skewes.

9. Irrigation Settlement Problems.

At Griffith Research Station, Griffith—
Liaison Officer—F. K. Watson, M.A., B.Sc., A.M.Inst.C.E., A.M.I.E. (part-time).
Officer-in-Charge—E. S. West, B.Sc., M.S.
Chemist—A. Howard, M.Sc., A.A.C.I.
Assistant Research Officer—R. R. Pennefather, B.Agr.Sc.
Assistant Research Officer—O. Perkman, B.Sc.Agr.
Orchard Superintendent—B. H. Martin, H.D.A.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (irrigation and viticulture)—D. V. Walters, M.Agr.Sc.
Assistant Research Officer (drainage)—A. L. Tisdall, M.Agr.Sc.
Assistant Research Officer (chemist)—P. Dixon, M.Sc.
Technical Officer—J. E. Giles.
Research Officer—A. C. Ingerson (part-time).
Research Officer—R. C. Polkinghorne (part-time).

10. Division of Forest Products.

At South Melbourne—
Administration—
Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E. (Aust.) (on leave).
Librarian and Records Clerk—Miss M. I. Hulme.

Chemistry Section—
Officer-in-Charge—W. E. Cohen, D.Sc., A.A.C.I.
Assistant Research Officer (chemist)—E. A. Hanson, Dr.Phil.(Leiden).
Assistant Research Officer (chemist)—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I.
Technical Officer—A. G. Charles, A.A.C.I.
Technical Officer—A. J. Watson, A.A.C.I.

Wood Structure Section—
Officer-in-Charge—H. E. Dadswell, D.Sc., A.A.C.I.
Assistant Research Officer—H. D. Ingle, B.For.Sc. (N.Z.).
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—Miss D. J. Ellis, B.Sc.

Seasoning Section—
Officer-in-Charge—C. S. Elliot, B.Sc.
Assistant Research Officer—G. W. Wright, B.E.
Assistant Research Officer—A. C. Pond, B.E. (Hons.) (seconded).
Technical Officer—J. T. Currie.

Timber Physics Section—
Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—P. H. Sulzberger, B.Sc.

Timber Mechanics Section—
Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E., A.M.I.E. (Aust.).
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Assistant Research Officer—N. H. Kloot, B.Sc.
Technical Officer—B. Whitington, B.Sc., B.E.
Technical Officer—A. L. Gunn.

Preservation Section—
Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer—N. Tamblyn, M.Sc.(Agric.).
Creosote Research Officer—D. E. Bland, M.Sc., A.A.C.I. (co-operative investigation with Tar Distillers).
Veneering and Gluing Section—
Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Technical Officer—R. Deeble.
Timber Utilization Section—
Officer-in-Charge—R. F. Turnbull, B.E. (Hons.).
Research Officer—A. J. Thomas, Dip.For.
Assistant Research Officer—C. E. Dixon, M.Sc., A.A.S.E.
Assistant Research Officer—A. Gordon, B.Sc.
Technical Officer—A. Rosel.
Flax Processing—
Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Research Officer—A. M. Munro, M.A. (Oxon.), A.I.C., F.C.S.
Assistant Research Officer—Miss J. F. Couchman, B.Sc., A.A.C.I.
Technical Officer—C. N. Pickering.
Technical Officer—J. S. Dobson.
Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.
Maintenance Section—
Technical Officer—S. G. McNeil.

11. Division of Food Preservation and Transport.

At State Abattoir, Sydney—
Chief—J. R. Vickery, M.Sc., Ph.D.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Physics Section—
Officer-in-Charge—E. W. Hicks, B.A., B.Sc., A.A.C.I.
Assistant Research Officer—M. C. Taylor, M.Sc.
Fruit Storage Section—
Officer-in-Charge—S. A. Trout, M.Sc., Ph.D.
Research Officer—F. E. Huelin, B.Sc., Ph.D., A.A.C.I.
Fruit Products Section—
Officer-in-Charge—L. J. Lynch, B.Sc.Agr.
Technical Officer—Mrs. I. M. Stephens, B.Sc.Agr.
Meat, Fish and Egg Technology Section—
Research Officer—W. A. Empey, B.V.Sc.
Assistant Research Officer—C. C. Kuchel, B.Sc., A.A.C.I.
Assistant Research Officer—J. F. Kefford, M.Sc., A.A.C.I.
Technical Officer—Miss N. Courtice, B.Sc.
Microbiology Section—
Officer-in-Charge—W. J. Scott, B.Agr.Sc.
Technical Officer—P. R. Maguire.
At Government Cool Stores, Melbourne—
Assistant Research Officer (plant physiologist)—H. S. McKee, B.A., D.Phil.
At Brisbane Abattoir—
Research Officer (biophysicist)—A. R. Riddle, M.A., M.Sc.
At Fisheries Research Laboratory, Cronulla—
Technical Officer (fish curing and canning)—R. Allan.
At Australia House, London—
Assistant Research Officer—N. E. Holmes, B.E.E.

12. Division of Fisheries.

At Port Hacking, Sydney—
Chief—H. Thompson, M.A., D.Sc.
Assistant Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
Assistant Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Assistant Research Officer (biologist)—G. L. Kesteven, B.Sc.

Assistant Research Officer (biologist)—M. Blackburn, M.Sc.
Assistant Research Officer (biologist)—A. Tubb, M.Sc.
Assistant Research Officer (chemist and hydrographer)—D. Rochford, B.Sc.
Technical Officer—A. Proctor (laboratory).
Technical Officer—G. Clark (M.V. *Warreen*).
Technical Officer—Mrs. M. Roger, B.Sc.
Clerk—W. J. Gillespie, A.F.I.A., A.A.I.A.
Master—M.V. *Warreen*—Captain A. Flett.

At Melbourne—
Fisheries Officer—S. Fowler.

13. Australian National Standards Laboratory.

Administration—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst.P.
Senior Clerical Officer—R. F. Williams.
Clerk, Registry—B. L. Mills.
Records—Miss U. Emanuel, B.Sc.
Librarian and Technical Recorder—Mrs. E. L. Eastman, B.A.
Draughtsman—R. H. Furniss.

Electrotechnology Section—
Officer-in-Charge—D. M. Myers, B.Sc., D.Sc.Eng., A.M.I.E.E., F.Inst.P.
Assistant Research Officer—W. K. Clothier, B.Sc., M.E., A.Inst.P.
Assistant Research Officer—B. V. Hamon, B.Sc., B.E.
Assistant Research Officer—A. M. Thompson, B.Sc.
Technical Officer—J. W. Porter.

Metrology Section—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst.P.
Assistant Research Officer—G. A. Bell, B.Sc.
Assistant Research Officer—P. M. Gilet, B.Sc., B.E.
Assistant Research Officer—C. G. Greenham, M.Sc. (seconded from Division of Plant Industry).
Assistant Research Officer—M. F. Lamrock, B.Sc., B.E.

Physics Section—
Officer-in-Charge—G. H. Briggs, D.Sc., Ph.D.
Assistant Research Officer—N. A. Faull, B.Sc.
Assistant Research Officer—R. G. Giovanelli, M.Sc.
Assistant Research Officer—A. F. A. Harper, M.Sc.
Technical Officer—J. E. Thompson.
Instrument Maker—F. G. Boland.

14. Division of Aeronautics.

Chief—L. P. Coombes, D.F.C., B.Sc., A.F.R.Ae.S.
Senior Draughtsman—D. W. Eaton.
Librarian—Miss A. L. Hicks, B.Sc. (part-time).

Aerodynamics Section—
Senior Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D., A.F.R.Ae.S.
Assistant Research Officer—T. F. G. Lawrence, B.Sc., B.E.
Assistant Research Officer—G. K. Batchelor, M.Sc.
Technical Officer—F. Redlich.

Structures and Materials Section—
Principal Research Officer—H. A. Wills, B.E., A.F.R.Ae.S.
Assistant Research Officer—J. B. Dance, B.Met.E.
Assistant Research Officer—H. W. Maley, B.E.
Assistant Research Officer—W. W. Johnston B.E.

Engines and Fuels Section—
Senior Research Officer—M. W. Woods, D.Phil., B.Sc., B.E.
Assistant Research Officer—W. B. Kennedy, B.Mech.E.
Technical Officer—T. M. Spiers.

Instruments Section—
Assistant Research Officer—A. A. Townsend, M.Sc.
Technical Officer—A. N. A. Clowes.

Photography—
Technical Officer—Miss E. F. Lightfoot.

Workshops—
Technical Officer—J. S. McLaren.
Technical Officer—A. Chilton.

15. Division of Industrial Chemistry.

Administrative and General—
Chief—I. W. Wark, Ph.D., D.Sc., F.A.C.I., M.A.I.M.E.
Principal Research Officer—E. J. Drake, A.A.C.I. (seconded).
Divisional Secretary—L. Lewis, B.Met.E.
Assistant Research Officer—E. H. Waters, M.Sc. (seconded).
Clerk—A. Patterson, A.F.I.A.
Librarian—Miss A. L. Hicks, B.Sc. (part-time).

Leather and Fellmongery Section—
Research Officer—F. G. Lennox, M.Sc., A.A.C.I.
Assistant Research Officer—W. J. Ellis, A.S.T.C.
Assistant Research Officer—Miss M. Maxwell, M.Sc.

Minerals Section—
Senior Research Officer—R. G. Thomas, B.Sc., A.A.C.I.
Assistant Research Officer—A. Wylie, M.Sc., Ph.D.(Lond.), A.A.C.I.
Technical Officer—Miss M. Page, B.Sc.

Dairy Products Section—
Research Officer—G. Loftus Hills, B.Agr.Sc.

Organic Section—
Senior Research Officer—H. H. Hatt, B.Sc., Ph.D.(Lond.).
Assistant Research Officer—K. E. Murray, B.Sc., A.A.C.I.

Physical Chemistry Section—
Assistant Research Officer—K. L. Sutherland, M.Sc., A.A.C.I.
Assistant Research Officer—J. Rogers, M.Sc., A.A.C.I.
Assistant Research Officer—Miss E. Plante, B.Sc.

Wool Section—
Assistant Research Officer—M. Lipson, B.Sc., A.A.C.I.
Assistant Research Officer—E. H. Mercer, B.Sc. (seconded from Division of Animal Health and Nutrition).
Technical Officer—Miss C. Clyne, B.Sc.

Foundry Sands Investigations—
Assistant Research Officer—H. A. Stephens, B.Sc.

Alunite Investigations—
Assistant Research Officer—G. H. Payne, B.Sc., A.A.C.I.
Assistant Research Officer—W. E. Ewers, B.Sc.

Chemical Engineering Section—
Designing Draughtsman—C. Simpson.
Assistant Research Officer—D. R. Zeidler, M.Sc.

16. Section of Biometrics.

At Melbourne—
Senior Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Assistant Research Officer—E. J. Williams, B.Com.

At Canberra—
Assistant Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.

At Sydney—
Assistant Research Officer—Miss H. A. Newton Turner, B.Arch.

17. Radio Research.

At University of Sydney—
Investigator—F. W. Wood, B.Sc.
Investigator—L. S. Prior, B.Sc.

18. Ore-dressing Investigations.

At University of Melbourne—
Investigator—J. G. Hart.
At School of Mines, Adelaide, South Australia—
Investigator—K. S. Blaskett, B.E.

19. Other Investigations.

Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Research Officer—A. Edwards, B.Sc., Ph.D.
Lubricants and Bearings Investigations—
Officer-in-Charge—P. Bowden, Sc.D.(Cantab.).
Assistant Research Officer—D. Tabor, B.Sc., A.R.C.S., Ph.D. (Cantab.).
Assistant Research Officer—L. T. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer—H. W. Worner, M.Sc., A.A.C.I.
Assistant Research Officer—G. W. Alexander, B.C.E., A.M.I.E.Aust.
Assistant Research Officer—J. Courtney-Pratt, B.E.
Dairy Products Investigations—
At School of Dairy Technology, Werribee—
Officer-in-Charge—W. J. Wiley, D.Sc., A.A.C.I.
Research Officer—E. J. Pont, M.Sc.(Agr.).
Assistant Research Officer—C. C. Thiel, B.Sc.(Agr.), Ph.D.

4. *Publications of the Council.*—The following publications were issued by the Council during the year :—

(i) *Bulletins.*

No. 134.—Studies on Bovine Mastitis. 1.—Study of an Experimental Herd—From the Division of Animal Health and Nutrition.

No. 135.—Investigations on the Storage of Jonathan Apples grown in Victoria, by S. A. Trout, M.Sc., Ph.D., G. B. Tindale, B.Sc.Agr., and F. E. Huelin, B.Sc., Ph.D.

No. 136.—Experimental Studies of Ephemeral Fever in Australian Cattle, by I. M. Mackerras, M.B., Ch.M., B.Sc., M. J. Mackerras, M.B., M.Sc., and F. M. Burnet, M.D., Ph.D.

No. 137.—A Soil Survey of the Red Cliffs Irrigation District, Victoria, by G. D. Hubble, B.Ag.Sc., and R. L. Crocker, B.Sc.

No. 138.—The Economic Biology of Some Australian Clupeoid Fish, by M. Blackburn, M.Sc.

No. 139.—The Soils of Tasmania, by C. G. Stephens, M.Sc., A.A.C.I.

No. 140.—Foot-rot in Sheep : A Transmissible Disease due to Infection with *Fusiformis nodosus* (n. sp.). Studies on Its Cause, Epidemiology, and Control, by W. I. B. Beveridge, D.V.Sc.

(ii) *Pamphlets.*

No. 100.—Studies on the Marketing of Fresh Fish in Eastern Australia. Part 2.—The Bacteriology of Spoilage of Marine Fish, by E. J. Ferguson Wood, M.Sc., B.A.

No. 101.—Studies of the Physiology and Toxicology of Blowflies.
(2) The Action of Stomach Larvicides on *Lucilia cuprina*, by F. G. Lennox, M.Sc., A.I.C.
(3) The Toxicity of Some Arsenicals to Larvae of *Lucilia cuprina*, by F. G. Lennox, M.Sc., A.I.C., and L. G. Webber.
(4) The Action of Contact Larvicides on *Lucilia cuprina*, by F. G. Lennox, M.Sc., A.I.C.

No. 102.—Studies of the Physiology and Toxicology of Blowflies.
(5) The Hydrogen Ion Concentration in the Alimentary Canal, by D. F. Waterhouse, M.Sc.
(6) The Absorption and Distribution of Iron, by D. F. Waterhouse, M.Sc.
(7) A Quantitative Examination of the Iron Content of *Lucilia cuprina*, by F. G. Lennox, M.Sc., A.I.C.

No. 103.—An Examination of Some Australian Hardwood Charcoals with Special Reference to Their Suitability for Charcoal Gas Producers, by J. N. Almond, B.Sc., B. M. Holmes, M.Sc., and Enid C. Plante, B.Sc.

No. 104.—The Australian Tunas, by D. L. Serventy, B.Sc., Ph.D.
No. 105.—The Biology and Cultivation of Oysters in Australia. 1.—Some Economic Aspects, by G. L. Kesteven, B.Sc.
No. 106.—A Report on Agricultural Features of the Australian Potato Industry, by J. G. Bald, Ph.D., M.Agr.Sc.
No. 107.—Food Composition Tables, compiled by Hedley R. Marston, and Mary C. Dawbarn.

(iii) *Trade Circulars.*

No. 47.—Nomenclature of Australian Timbers.

(iv) *Food Preservation Circular.*

No. 1-P.—The Commercial Ripening of Bananas (second edition—revised).

(v) *Quarterly Journal.*

Vol. 13, No. 3, August, 1940.
Vol. 13, No. 4, November, 1940.
Vol. 14, No. 1, February, 1941.
Vol. 14, No. 2, May, 1941.

(vi) *Annual Report for the year ending 30th June*, 1940.

XVI. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made to the valuable assistance afforded by many organizations and individuals. The Council desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. In particular, it desires to make special reference to the help given by the various State Departments, particularly those of Agriculture, and by the Universities, and to the contributions either in money or in kind provided by such bodies as the Commonwealth Bank (from its Rural Credits Development Fund), the New South Wales State Government, the Australian Wool Board, the Australian Meat Board, the George Aitken Pastoral Research Trust, the Australian Cattle Research Association, the Australian Dried Fruits Control Board, and by other bodies, companies, and individuals. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, the members of which have placed their knowledge and experience so freely at its disposal.

G. A. JULIUS, Chairman,
DAVID RIVETT,
A. E. V. RICHARDSON,
} Executive Committee.

G. LIGHTFOOT, Secretary.
10th September, 1941.

APPENDIX.

A.—PERSONNEL OF THE COUNCIL AND OF ITS VARIOUS COMMITTEES.

COUNCIL (AS AT 30TH JUNE, 1941).

Executive.

Sir George A. Julius, Kt., D.Sc., B.E. (*Chairman*).
Sir David Rivett, K.C.M.G., M.A., D.Sc. F.R.S., F.A.C.I. (*Deputy Chairman and Chief Executive Officer*)
A. E. V. Richardson, C.M.G., M.A., D.Sc. (*Deputy Chief Executive Officer*).

Chairmen of State Committees.

Professor R. D. Watt, M.A., B.Sc. (New South Wales).
Russell Grimwade, C.B.E., B.Sc. F.A.C.I. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
T. E. Field (South Australia).
E. H. B. Lefroy (Western Australia).
P. E. Keam (Tasmania).

Co-opted Members.

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G. S. Colman, C.B.E.
Professor E. J. Goddard, B.A., D.Sc.
Professor H. A. Woodruff, B.Sc., M.R.C.V.S., M.R.C.S., L.R.C.P.

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J. Merrett.
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E. D. Ogilvie, B.A.
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W. Baragwanath.
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Emeritus-Professor Sir Thomas R. Lyle, Kt., M.A., D.Sc., F.R.S.
H. A. Mullett, B.Agr.Sc.
B. Perry, A.A.C.I.
F. J. Rae, B.A., B.Sc., B.Agr.Sc.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M.
L. J. Weatherly, M.A.
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South Australia.

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C. E. Chapman, F.I.C., F.A.C.I.
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Professor Kerr Grant, M.Sc., F.Inst.P.
Professor T. H. Johnston, M.A., D.Sc.
F. T. Perry.
Professor J. A. Prescott, D.Sc., A.A.C.I.
W. J. Spafford, R.D.A.
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Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
P. Malloch, Commonwealth Dried Fruits Control Board.
E. J. Casey, Commonwealth Dried Fruits Control Board.

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Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.

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E. J. Casey (representing Consultative Committee).
J. Gordon, Citrus Growers' Association, Merbein.
W. Grundy, Nyah, Victoria.
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W. Heaysmen, Cardross Horticultural Society.
A. Lever, Mildura Shire Council.
J. A. Lockhead, Mildura Shire Council.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
A. R. McConchie, State Rivers and Water Supply Commission, Red Cliffs, Victoria.
A. Rawlings, Merbein Growers' Union.
S. P. Taylor, Curlwaa, New South Wales.
F. K. Watson, M.A., B.Sc(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.
O. Weste, Renmark, South Australia.

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A. G. Kubank, Murrumbidgee Irrigation Rice Growers' Co-operative Society.
V. W. Letheren, Leeton Fruitgrowers' Co-operative Society Ltd.
O. J. Longhurst, Yenda Producers' Co-operative Society Ltd.
T. T. Morley, Griffith Producers' Co-operative Co. Ltd.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
H. J. Williams, Leeton Co-operative Cannery Ltd.
V. C. Williams, Murrumbidgee Irrigation Areas Research Bureau, Griffith.

FRUIT PROCESSING COMMITTEE.

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A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith, New South Wales.
D. Quinn, Department of Agriculture, Victoria (*Secretary*).

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T. C. Roughley, B.Sc., Chief Secretary's Department, Sydney.
H. Thompson, M.A., D.Sc., Chief, Division of Fisheries, C.S.I.R.

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E. H. B. Lefroy, Chairman, State Committee, C.S.I.R.
C. F. Jenkins, B.A., Entomologist, Department of Agriculture, Western Australia.
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I. Thomas, Department of Agriculture, Western Australia.
A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
L. W. Phillips, M.Sc., M.Ed., A.A.C.I., Technical College, Perth (*Secretary*).

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(*Formerly the Interdivisional Blowfly Committee ; its function is to co-ordinate certain activities of the Divisions of Economic Entomology and of Animal Health and Nutrition.*)

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A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Nutrition, C.S.I.R.

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Eric P. Beresford, Moonjaree, Cunnamulla, Queensland.
W. S. Geary, Carbean, Offham Siding, Western Line, Queensland.
R. H. Nantes, Queensland United Graziers' Association.

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E. J. Bowater, Messrs. Angliss & Co. Pty. Ltd., Sydney.
J. M. Davidson, Commonwealth Veterinary Officer, Sydney (representing the Department of Commerce).
J. Merrett, Metropolitan Meat Industry Commissioner, Sydney.
F. J. Walker, Sydney.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

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D. McVey, Director-General, Postmaster-General's Department, Melbourne.
Commander J. B. Newman, R.A.N., Department of the Navy, Melbourne.

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F. J. Shea, Department of Supply and Development, Melbourne.
J. Storey, Aircraft Production Commission.
G. Lightfoot, M.A., Council for Scientific and Industrial Research.
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SCIENTIFIC PUBLICATIONS COMMITTEE.

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Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., F.A.C.I., Council for Scientific and Industrial Research.
J. H. L. Cumpston, C.M.G., M.D., D.P.H., Department of Health, Canberra.

TECHNICAL COMMITTEE—PASTURE PLANT IMPROVEMENT INVESTIGATION, QUEENSLAND.

Professor J. K. Murray, B.A., B.Sc.Agr., Queensland Department of Public Instruction.
C. W. Winders, B.Sc.Agr., Department of Agriculture and Stock, Brisbane.
J. R. A. McMillan, B.Agr.Sc., M.S., D.Sc. (with C. S. Christian, B.Sc.Agr., M.Sc., as deputy), C.S.I.R.
B. T. Dickson, B.A., Ph.D., C.S.I.R., *ex officio* member.
R. Veitch, B.Sc.Agr., B.Sc.For., F.R.E.S., Department of Agriculture and Stock, Brisbane.

IRRIGATION AND DRAINAGE COMMITTEE FOR SOUTH AUSTRALIA.

C. M. Fowles, Secretary for Irrigation, Lands Department, South Australia (*Chairman*).
A. G. Strickland, M.Agr.Sc., Chief Horticultural Instructor, Department of Agriculture, South Australia.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
A. C. Gordon, Superintendent for Irrigation, Lands Department, South Australia.
E. R. Laurie, Engineer for Irrigation, Engineering and Water Supply Department, South Australia.

CURLWAA AND COOMEALLA HORTICULTURAL ADVISORY COMMITTEE, NEW SOUTH WALES.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
F. S. Barrett, Water Conservation and Irrigation Commission, New South Wales.
S. Colley, Rural Bank, New South Wales.
F. S. Oldham, Department of Agriculture, New South Wales.
W. Webley, Coomealla Settlers' Representative.
S. P. Taylor, Curlwaa Settlers' Representative.
A. L. Tisdall, Commonwealth Research Station, Merbein (*Secretary*).

WAKOOL DISTRICT RESEARCH COMMITTEE, NEW SOUTH WALES.

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T. J. Marshall, M.Agr.Sc., Ph.D., Division of Soils, C.S.I.R.
G. B. Gibb, Water Conservation and Irrigation Commission, New South Wales.
J. M. Arthur, Department of Agriculture, New South Wales.
F. Mathews, Rural Bank, New South Wales.
E. E. Ellis, H. J. Jackson, R. Redfearn } representing Landholders (Wakool Irrigation Area).

ADVISORY COMMITTEE ON WATERLOGGING PROBLEMS.

(*This Committee was formed by the Leeton Fruit-growers' Co-operative Society to advise settlers in cases where they have some difficult irrigation problem.*)

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C. G. Savage, Department of Agriculture, New South Wales.
A. G. Enticknap, M.I.A., Co-operative's Executive, Yenda.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.

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C. J. Horth, Department of Agriculture, New South Wales.
E. C. Connor, Department of Agriculture, New South Wales.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.
J. G. Youll, Water Conservation and Irrigation Commission, Leeton.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, Leeton.
E. R. Iredale, Rural Bank, New South Wales.
C. T. Lasscock, Rural Bank, New South Wales.
H. G. B. Williams, Rural Bank, New South Wales.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.
V. C. Williams, M.I.A. Co-operatives Executive, Griffith.
A. G. Enticknap, M.I.A. Co-operatives Executive, Yenda.
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A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
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W. Heaysman, Merbein Advisory Committee.
W. R. Jewell, M.Sc., B.Met., Victorian Department of Agriculture.

Growers' Representatives.

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J. Moore, Red Cliffs.
D. Taylor, Dareton, New South Wales.
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G. S. Potts, Mildura.
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H. Broadfoot, Department of Agriculture, New South Wales.
Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
Professor E. Ashby, D.Sc., Department of Botany, University of Sydney.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
S. A. Trout, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS.

(*Established in connexion with the co-operative investigations of the Council and the Victorian Department of Agriculture on the cool storage of non-tropical fruits.*)

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F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

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A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
T. D. Raphael, M.A., Dip.Hort. (Cambridge), Department of Agriculture, Tasmania.
W. M. Carne, Department of Commerce, Melbourne.
Professor W. J. Young, D.Sc. (representing C.S.I.R.).
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D. Martin, B.Sc., Division of Plant Industry, C.S.I.R.

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R. P. Allen, Chief Veterinary Officer, Department of Commerce, Melbourne.
W. M. Carne, Fresh Fruit Officer, Department of Commerce, Melbourne.
E. J. Drake, A.A.C.I., Division of Industrial Chemistry, C.S.I.R.
I. W. Wark, Ph.D., D.Sc., F.A.C.I., M.A.I.M.E., Division of Industrial Chemistry, C.S.I.R.
F. Wigan, Supervisor of Dairy Exports, Department of Commerce, Melbourne.
W. J. Wiley, D.Sc., A.A.C.I., C.S.I.R.
I. Stewart, Investigation Officer, Department of Commerce, Melbourne.
H. C. Menzies, Department of Commerce, Melbourne (*Secretary*).

ADVISORY COMMITTEE ON ORIENTAL PEACH MOTH INVESTIGATIONS.

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H. J. Williams, Manager, Leeton Cannery, New South Wales.
G. A. H. Helson, M.Sc., Division of Economic Entomology, C.S.I.R.
S. Fish, M.Agr.Sc., Biologist, Department of Agriculture (Victoria), (*Secretary*).

JOINT BLOWFLY CONTROL COMMITTEE.

(*As a means of co-ordination of activities of New South Wales Department of Agriculture and of C.S.I.R.*)

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A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
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T. McCarthy, Chief Entomologist, Department of Agriculture, New SouthWales.
H. G. Belschner, D.V.Sc., Department of Agriculture, New South Wales.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Nutrition, C.S.I.R.

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P. A. Brown, Queensland United Graziers' Association.
G. A. Fairbairn, Queensland United Graziers' Association.
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W. J. Spafford, R.D.A., Department of Agriculture, South Australia.
G. K. Baron-Hay, M.C., B.Sc.(Agric.), Department of Agriculture, Western Australia.
F. W. Hicks, Department of Agriculture, Tasmania.
Ross Grant, Department of Commerce, Melbourne.
J. Proud, representing Australian Dairy Produce Board.
A. E. V. Richardson, C.M.G., M.A., D.Sc., Deputy Chief Executive Officer, C.S.I.R.
L. B. Bull, D.V.Sc., Division of Animal Health and Nutrition, C.S.I.R.
A. J. Vasey, B.Agr.Sc., Division of Animal Health and Nutrition, C.S.I.R. (*Secretary*).

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H. St. J. Somerset, Electrolytic Zinc Co. of Australasia Ltd., Melbourne.
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H. Hey, Electrolytic Zinc Co. Ltd., Melbourne.
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G. B. O'Malley, B.Met.E., Melbourne.
H. H. Dunkin, School of Metallurgy, University of Melbourne.
J. G. Hart, School of Metallurgy, University of Melbourne (*Secretary*).

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Professor Kerr Grant, M.Sc., F.Inst.P., Department of Physics, University of Adelaide.
R. W. Parsons, Bonython Laboratory, South Australian School of Mines and Industries (*Secretary*).

Kalgoorlie Sub-Committee.

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J. R. Hylton, Great Boulder Pty. Gold Mines Ltd., Fimiston, Western Australia.

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